The Engineer

APRIL 6, 1956 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

UNIVERSITY OF MICHIGAN
APR 25 1956
ENGINEERING LIBRARY

All types of shallow draft vessels for all parts of the world

'TAGOOG'—one of six quarter wheel pusher tugs for service in the Sudan.

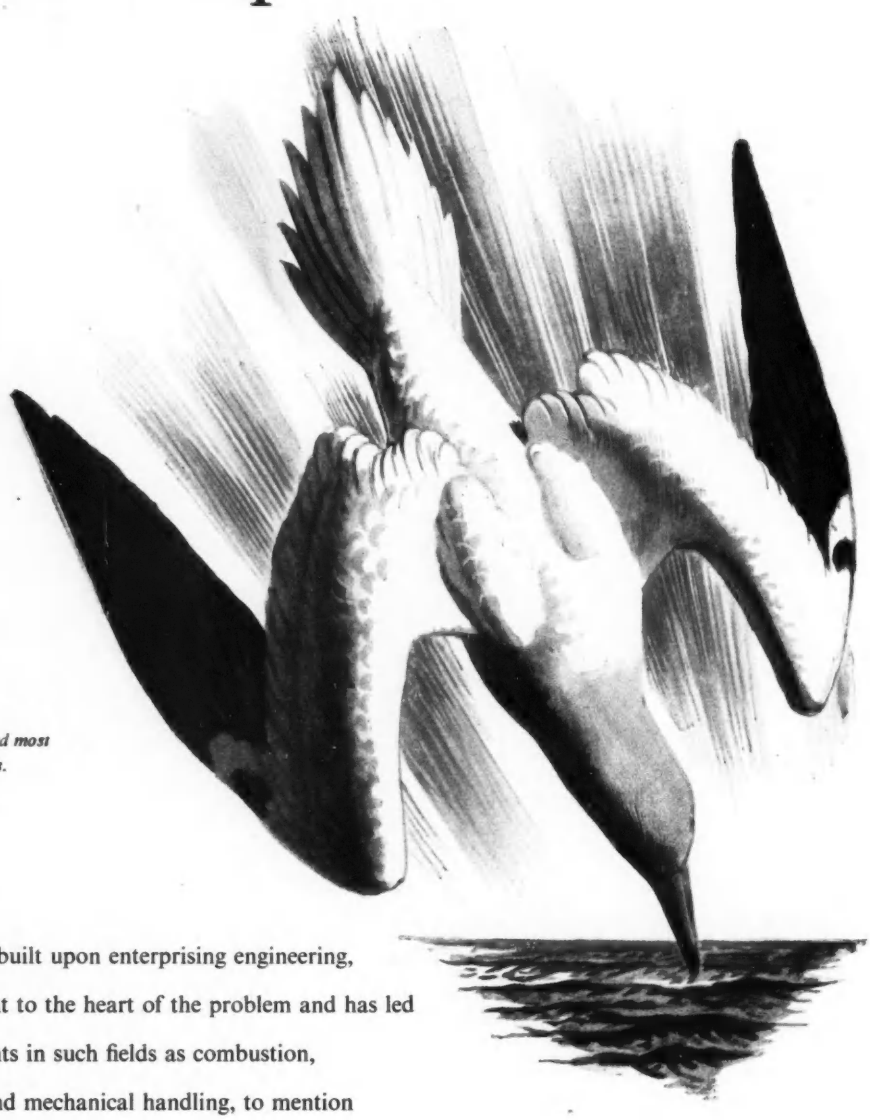
'CHINMA'—one of six twin screw tunnel type passenger vessels for service in Burma.

YARROW

* *Shipbuilders*
* *Engineers*
* *Boilermakers*

SCOTSTOUN · GLASGOW W.4

Straight to the point ...



The gannet, persistent and enterprising, is the largest and most powerful of Britain's seabirds.

IC's reputation has been built upon enterprising engineering, engineering that goes right to the heart of the problem and has led to significant improvements in such fields as combustion, steam raising, grinding and mechanical handling, to mention only a few. Perhaps you, too, would benefit from . . .

enterprising engineering by

IC

THE INTERNATIONAL COMBUSTION GROUP OF COMPANIES

comprising :

INTERNATIONAL COMBUSTION LIMITED · INTERNATIONAL COMBUSTION PRODUCTS LTD.
INTERNATIONAL COMBUSTION (EXPORT) LTD · RILEY (IC) PRODUCTS LIMITED

LONDON OFFICE: NINETEEN WOBURN PLACE · W.C.1 · TELEPHONE: TERMINUS 2833
WORKS: DERBY, ENGLAND · PORT ELIZABETH, SOUTH AFRICA · SYDNEY, AUSTRALIA

THE ENGINEER

VOL. 201 No. 5228 APRIL 6, 1956

CONTENTS

LEADING ARTICLES—
Nuclear Fuel 285
Boys and Careers 286

ARTICLES—
Automatic Co-ordinate Setting on a Horizontal Boring Machine. (Illus.) 290
British Industries Fair, London Section 287
British Trade Fair in Finland 287
Corrosion Resistant Lining for Ships' Oil Tanks. (Illus.)... 304
Effects of Vibration on Pitot Probe Readings. No. II. (Illus.) 288
Electrical Engineers' Exhibition. No. II. (Illus.) 299
Engravings of 1864... 298
" For the Record "... 295
Gas-Turbo Alternator 287
Institution of Naval Architects. No. I. 302
Load Simulator for Railway Formation Materials 307
Manufacture of the Free-Piston Engine 292
Mr. O. N. Chadwyck-Healey 287
National Institute of Agricultural Engineering 287
Oil Refining in Australia. No. II. (Illus.) 305
Prone Pilot " Meteor." (Illus.) 302
Retirement of Sir Rowland Smith... ... 287
Traffic Congestion in London 287
Wadi Tharthar Flood Protection Project in Iraq. (Illus.) 293
Waterproof Additive for Concrete ... 307
100 Years Ago 286

AMERICAN SECTION—
Progress of the Tennessee Valley Authority. No. I. (Illus.) 311

LITERATURE 297

NEWS AND NOTES—
British Patent Specifications. (Illus.) ... 315
British Standards Institution... 301
Catalogues and Brochures 316
Continental Engineering News. (Illus.) 308
Forthcoming Engagements 316
Industrial and Labour Notes... 310
Launches and Trial Trips 316
Personal and Business 314
Technical Reports 296

NUCLEAR FUEL

President Eisenhower's statement on February 22nd, that the United States is to release 40,000 kg of uranium-235, valued at $1000 million, for use in the development of atomic energy for peaceful purposes was unexpected, and the magnitude of the offer has aroused considerable astonishment. Half the uranium-235 is for use in the United States, and half will be made available to those nations not at present producing uranium-235. The offer marks a very important and welcome stage in the transition from military to peaceful applications of atomic energy and will undoubtedly quicken the interest of many countries which are contemplating building nuclear reactors. The terms of the offer are not yet clear. It is likely that the uranium-235 will be diluted with the non-fissile uranium-238 so that the concentration of 235 will be insufficient for military use. Thus the enrichment may be 10 or 20 per cent compared with the 0·7 per cent of naturally occurring uranium. It is possible for this offer to affect the whole line of development of nuclear energy in many countries. For example it will certainly have to be taken into account when considering what form atomic energy developments should take on the European continent, and whether or not a plant for separating the isotopes of uranium should be built. According to President Eisenhower, the uranium-235 will be made available by sale or lease outside the United States. In the present climate of political opinion it is most unlikely that such fuel would be sold outright ; but instead it is much more probable that the United States, through some agency, would wish to retain control on the chemical reprocessing of the fuel in order to maintain a check on the plutonium that would result from its irradiation in the reactor. If this course was adopted then there would inevitably need to be a strong link between the agency supplying the fuel elements, and the reactor designers in the first place : and in the second a close tie between the agency and the reactor operators, as, on present economic calculations, the cost of reprocessing the fuel is a major factor in the cost of electrical power generated.

The offer, and the political desirability of maintaining control of fissile material, underlines one of the major problems that face British manufacturers in the overseas market. As a nation that depends for its standard of living on its export trade, and to a significant extent within that trade on its engineering firms, it is essential that this country can compete successfully for overseas orders for nuclear reactors. So far it has been stated that, while British manufacturers will be certain of receiving any amount of natural uranium they require for reactor fuel, the supply of enriched material is limited. At present the groups of industrial firms engaged in the design of power reactors are preparing designs for improved versions of the Calder Hall type of reactor. This reactor is designed for burning natural uranium and it is this type of reactor manufacturers will be able initially to offer to overseas customers. One of the drawbacks of the reactor fuelled with natural uranium is that it must be large in order to achieve a critical assembly. In addition, as poor neutron economy can only be offset by making the reactor even larger, the choice of fuel canning materials and other neutron absorbers in the reactor core is very limited. There is scope for using slightly enriched fuel to ease the latter problems, and probably some economies can be effected in this way ; but in general this type of reactor is best suited to the large base-load power station. With more highly enriched fuel a greater variety of reactors is possible and for smaller power plants such fuel is essential. Thus, for the present at any rate, British chances in the export market are likely to be confined to those countries which wish to build large power stations ; whereas, on the face of it, it would appear that American firms will be much freer to adapt their designs to the need of the country concerned.

It would however be wrong to underestimate our present position in this new industry. The economics of power production from atomic energy are least clear when it comes to comparing one type of reactor with another, and this is particularly so when attempting to assess the merits of the more advanced types. One of the soundest selling points that British industry will have to back its efforts to export gas-cooled thermal reactors will be the fact that such reactors are being built for power production in this country. Calder Hall goes into operation this year, and from then onwards there will be an ever-increasing accumulation of operating data and costs on this class of power station. So much for the next few years: what of the future ? Undoubtedly, we shall fall behind in reactor technology if our choice of designs is limited by lack of enriched fuel. But it is not simply a matter of there being a firm and necessarily continuing demand for enriched uranium which justifies the

immediate construction of more diffusion plant capacity. It must be remembered that one of the by-products of the nuclear power programme in this country will be plutonium. Unless therefore the production of uranium-235 for civil reactor use is matched carefully to the nuclear power programme and to any programme for building reactors for marine and air use, the present shortage of enriched fuel could be replaced in a few years' time by an overproduction of very costly fissile material.

BOYS AND CAREERS

When do boys make up their minds about the careers they intend to adopt ? Most of the present generation of grown-ups, we suspect, evinced at a very tender age a determination to be engine drivers. Perhaps the present generation of juniors has more catholic tastes. But upon maturer consideration, whatever the life's work at first chosen, enthusiasm later wanes. The time for earning a living seems so far off that it is no longer worth bothering about a future career when for the present there are so many other exciting things to do. Even when the choice has to be made whether or not to go on the science side the boy's views may be coloured as much by the understanding that some hateful subject such as Latin does not figure in the science side curriculum as by a real interest in science ! As often as not it is parents and masters who have to make the choice rather than the boy, judging partly by the boy's aptitudes and partly by their own ideas of the advantages of various professions. When the parents are well-read and have a varied acquaintance the choice may be well-founded. But when the boy comes from a comparatively uncultured home, as many aspiring to university courses now do, when neither the parents nor their friends have much appreciation of the possibilities opening before the boy, it is to be feared that mistakes are made, at first as between arts and science and later upon entrance to the university where specialisation becomes more complete. Too few opt for technology.

Particularly at the present day it may be doubted whether all those youngsters, the bent of whose minds would suit them admirably for a technological career, are brought to a realisation by parents or masters that so interesting and attractive a career is open to them. That is a point the significance of which is becoming increasingly realised by technological bodies. For the proportion of university students studying technology, at a mere 12 per cent of the university student population, is really deplorably low for a country which was once the workshop of the world and must depend for future prosperity primarily on its technological achievements. Statistics indicate that per thousand of the population this country's output of engineers of graduate level is less than half that of the U.S.A. and only a fifth of that of Russia. Those statistics are alarming. They remain alarming even if it can justifiably be contended that they exaggerate this country's deficiency by failing to take account of the effect of National Certificate schemes. For it is not known how many men are educated in U.S.A. and Russia to comparable standards. Nor can very much comfort be gleaned from the Government's plans for expanding facilities for technological education. For, allowing for the bulge in the school leaving population due to a high birth rate in the immediate post-war years, they appear to be based more upon the assumption that the same proportion of boys from any age-group will go to a university in future—which would add 50 per cent to the number of students by 1967—than upon the assumption that the proportion ought to rise by, say, 5 per cent per annum, which would double the number of students by 1967. Yet, despite the high and growing demand within industry for trained technologists, the Government can hardly be blamed. For of what use would it be to double the capacity of universities to teach technologists if insufficient students came forward ? That is not an idle fear. Between 1950 and 1954, degrees and diplomas in technology awarded by British universities actually contracted from 3593 to 3359, presumably because the full capacity of universities to absorb students was not taken up. If facilities for technological education are to be expanded really quickly there must be a high demand not only for the product but also for places in universities and colleges awarding degrees or their equivalent. In short, the attack needs to be directed at the schoolboy stage to convince boys, masters and parents alike of the opportunities available in a technological career.

There are several methods of staging that attack. Two deserve particular notice here because they relate to current events. Next week at the Institution of Mechanical Engineers, three lectures intended for teen-age audiences, will be delivered on successive days, the first on "Fundamental Energy," by Professor Christopherson, the second, on "Applied Energy," by Sir Claude Gibb, and the third, on "Nuclear Energy," by Sir Christopher Hinton. It is intended that at this season every year similar lectures will be delivered and it is hoped that very soon these "Leonardo da Vinci Lectures" will establish as much fame for themselves as the Christmas lectures of the Royal Institution. It is immensely encouraging to learn that upon this first venture the demand for tickets was so great that some degree of rationing had to be imposed upon schools asking for them. The influence of such lectures delivered year after year, in helping boys to make up their minds, may well prove quite out of proportion to the number of boys that can actually attend them. Further satisfaction is to be gleaned from the rapidity of the response to the I.C.I. Scholarship Scheme, details of which we printed last week. These scholarships are offered to boys who did not study science at school but who wish to take a scientific subject at a university. The response suggests that some at least of those who now enter universities on the arts side would have preferred, if they had been able, to read science and are thus often lost to technology though they may have a bent for it. The impression given by these two events is that the figure of 12 per cent of university students studying technology reflects not a lack of interest amongst boys in these subjects but a lack of appreciation amongst parents and masters of the rewards and opportunities that technology offers.

100 Years Ago
The Engineer
(APRIL 4, 1856)

"ENGINEERS' SHARE IN THE LATE WAR"

"The advent of peace naturally suggests the inquiry as to what share engineers have had in bringing it about. Although a great deal of misconception prevails with regard to the value of mechanical contrivances in warfare, engineers may at least safely claim the merit of having overcome what was the grand difficulty in the siege of Sebastopol, the communication between Balaklava and the camp. If to this we add the facilities which steam navigation afforded for the rapid conveyance of men and stores between our depots and the theatres of war it will be conceded that engineers 'have done the state some service.'

"With regard to the various mechanical appliances with which, according to newspaper paragraphs, the Russians were to be killed wholesale—what have they done ? What has been done by the mysterious machines which, from a safe distance, were to rain death and destruction on us ? Really nothing, beyond affording a little amusement to those against whom they were to be directed. Our sailors fished up the '*infernal machines*' with as much ease as if they had been so many lobsters, or other marine crustaceans; and beyond smashing some crockery in one of our steamers they have done us no injury. The truth is, that the part which mere mechanical ingenuity can take in warlike operations on a grand scale is very slight, and its importance has been much overestimated.

"Battles are not won, or kingdoms subdued by new inventions ; but by the right direction of the accumulated force of every faculty which men possess."

EMERGENCY ISSUES
REFUND TO SUBSCRIBERS

The price of single copies of the six emergency issues of THE ENGINEER February 24th—March 30th, published during the recent printing dispute, was reduced to 6d. Will direct postal subscribers who wish to claim a refund of 1s. 6d. each in respect of these please write to The Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2.

A Seven Day Journal

Mr. O. N. Chadwyck-Healey

On March 31st, Mr. Oliver N. Chadwyck-Healey relinquished the chairmanship of Morgan Brothers (Publishers), Ltd., proprietors of THE ENGINEER, which position he has occupied since 1948. He will continue to serve on the board of the company. Mr. Chadwyck-Healey has been a director of Morgan Brothers (Publishers), Ltd., since the formation of the present company in 1929, and prior to becoming chairman was managing director for a period of sixteen years. His active association with the management of this journal goes back over many years, and from 1919 until 1929 he was managing director of "The Engineer," Ltd., the owning company. Mr. Chadwyck-Healey is succeeded as chairman of Morgan Brothers (Publishers), Ltd., by Sir Austin Hudson, Bt., M.P.

Traffic Congestion in London

THE subjects raised on the motion for the adjournment of the House of Commons for the Easter recess on March 29th included traffic congestion in London. The matter was introduced by Mr. John Foster, who made various suggestions about the parking of vehicles, the use of parking meters and the regulation of traffic flow. In traffic matters, Mr. Foster asserted, we had "always been behind technical advance, lessons which we should have learnt from other countries, and common sense." A reply to points raised in the debate was made by Mr. Hugh Molson, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation. He said that the Government looked forward to the time when it would be possible to carry out large measures of road construction in London. But to make it possible for every one who came into London to work to travel in his own car in the morning and to return in the evening was something which we could never attain! Mr. Molson went on to say that he wanted to make it quite plain that the Government had no intention whatsoever of subsidising "off-the-street" car parks. At a time when subsidies were being reduced, it would be difficult to justify subsidising car parks for those people who chose to come to London and leave their cars there. It was necessary, therefore, that the motorists should provide the money for the accommodation of their cars, and by means of parking meters and, it might be, of the provision of parking places with attendants where a charge would be made, the money would accumulate and could be used for the purpose. Under the provisions set out in the Road Traffic Bill, the whole of the proceeds of parking meters would be used for car parks.

Gas Turbo-Alternator

THE 10,000kW gas turbine alternator at the National Gas Turbine Establishment has now been run up and synchronised with the national grid. The power unit, built by C. A. Parsons and Co., Ltd., is intended both to shed light on the problems confronting industrial gas turbines and to lessen the demands of the powerful test installations upon the grid. The installation is believed to be the first in which a gas turbine has provided heat for a district heating system; the power and heat provided together give an efficiency of 40 per cent. The power unit is a two-line design, the high-pressure turbine and compressor running at 3000 r.p.m. and being coupled to the alternator. Intercooling and heat exchange are incorporated and distillate fuel is burnt.

British Industries Fair, London Section

THE President of the Board of Trade, Mr. Peter Thorneycroft, made a statement in Parliament on March 27th about the London section of the British Industries Fair. He recalled that in 1954 the Board of Trade's responsibility for the London section was transferred to British Industries Fair, Ltd., a company specially formed for the purpose. The Treasury had guaranteed £100,000 to the company and the Board of Trade had made annual grants for publicity. But, Mr. Thorneycroft continued, it was clear that the London section of the B.I.F. in its traditional form no longer met a general need, since most traders preferred to take part in specialised shows in which attention could be focused on the products of a particular industry. There had been a consequent decline in interest in the Fair, on the part of both buyers and exhibitors. In spite of all that had been done by British Industries Fairs, Ltd., Mr. Thorneycroft went on, the results of the Fairs in 1955 and 1956 were such that the directors had stated that the Treasury guarantee of £100,000 would be insufficient to enable the company to carry on and meet its liabilities. After full consideration, the Government had decided that it would not be right to provide public money for the B.I.F. in London, and the forthcoming Fair at Olympia would, therefore, be the last in London. The Birmingham Chamber of Commerce, Mr. Thorneycroft added, intended to continue the Fair at Castle Bromwich. He said also that the Government intended that the money hitherto spent on publicity for the London B.I.F. would in future be used by the Board of Trade mainly in connection with overseas fairs and exhibitions at which British goods were shown. The Government would consider, in consultation with the main industrial organisations concerned, how that could most effectively be done.

British Trade Fair in Finland

AT a speech which he made last week at the annual meeting of the Finnish-British Trade Association, Sir Norman Kipping, director-general of the Federation of British Industries, announced plans for an all-British trade fair at Helsinki in September, 1957. He said that the fair would be sponsored jointly by the Federation of British Industries, the London Chamber of Commerce and the Finnish-British Trade Association, and would be organised by British Overseas Fairs, Ltd. (a subsidiary of the F.B.I.). The fair, Sir Norman stated, would be held in the Messuhalli, in Helsinki, where there would be about 50,000 square feet of exhibition space in the two halls, with plenty of space outside for open-air exhibits. Sir Norman pointed out that British exports to Finland last year reached a value of £42,000,000, which was exactly double the 1953 figure. Britain, he said, was Finland's largest supplier, accounting for 20 per cent of her imports, and also her biggest customer, taking 25 per cent of her exports. The recent Anglo-Finnish trade talks, he continued, held out good hopes of further liberalisation of trade and an increase in imports from Britain. Finland needed much equipment for the mechanisation of agriculture and forestry and for the expansion of her industrial production, which had already doubled compared with pre-war.

Retirement of Sir Rowland Smith

A FEW days ago Sir Rowland Smith, M.I.Mech.E., announced that at the annual general meeting of Ford Motor Company, Ltd., on April 20th, he would retire from the chairmanship, but would continue as a director. Sir Rowland, who is now in his sixty-ninth year, entered the motor industry fifty-two years ago as an apprentice with Humber, Ltd., subsequently becoming a jig and tool designer with the firm. He went out to India in 1912 to take an appointment as works manager in an engineering concern, and a little later became manager of Ford Motors (Calcutta), Ltd. He joined the sales department of Ford Motor Company (England), Ltd., at Manchester, in 1924. When the present company was formed in 1928, Sir Rowland was appointed general manager, a position which he occupied for the next ten years, in the early part of which the transfer to the new plant at Dagenham was completed. Just before the war, Sir Rowland was elected to the board and in 1941 he became managing director. Sir Rowland was appointed deputy chairman of Ford Motor Company, Ltd., in 1948, and chairman two years later. He is to be succeeded as chairman by Sir Patrick Hennessy, who will continue to hold the office of managing director of the company.

National Institute of Agricultural Engineering

THE latest annual report to be published by the National Institute of Agricultural Engineering deals with the year ended September 30, 1955. It surveys the work carried out at the Institute's headquarters at Wrest Park, Silsoe, Bedfordshire, and at the Scottish station at Howden, Midlothian. In an introduction to the report, the director of the Institute, Mr. W. H. Cashmore, mentions visits made by himself and members of his staff to Colonial territories. During the year reviewed these visits included one to East Africa to look into the possibilities of setting up a mobile testing unit to serve Uganda, Kenya and Tanganyika. Mr. Cashmore says that the great need for such a service was evident, and plans have already been drawn up for sending out a team trained at the Institute. Mr. Cashmore mentions also the strengthening of the testing department at Wrest Park by the addition of staff with engineering qualifications to assist in the development of special apparatus and equipment. The report says that this "engineering bias" has made it possible to examine more closely the causes of mechanical failures during tests, and to advise manufacturers on steps for improvements. Moreover, investigations of an engineering nature, such as the wear and abrasion of metals working in the soil, have been added to the programme. One section of the report is concerned with the work of the mechanical engineering department at Wrest Park, which is done under the guidance of Mr. H. J. Hamblin. Among the special equipment for research which has been developed in the department there is mention of a hydraulic loading car which is now in constant use, providing a maximum load of 10,000 lb in bottom gear and 5500 lb in top. There is also a reference to a tractor "treadmill," which has been used for various experiments on the tractor equipped with hydraulic transmission, which itself is one of the mechanical engineering department's noteworthy achievements.

Effects of Vibration on Pitot Probe Readings

By F. A. L. WINTERNITZ, Dipl.-Ing.*

No. II—(*Concluded from page 275, March 30th*)

In continuation and extension of a recent report (THE ENGINEER, *May 27th*, 1955, *page* 729), *this article analyses the effects of vibration on the readings of cantilevered pitot cylinders, investigated by towing through water, by artificial vibration in still air or water, and in a water tunnel. The results of observations made for pitot tubes with support struts of round and aerofoil section are included. Calculations based on simplifying assumptions are shown to give a useful indication of the critical velocity of flow at which vibration is likely to commence. The results are presented in graph form, and may be used as a guide in probe design. The form of instability involved has also been the subject of a recent article in* THE ENGINEER (*Scruton, C., "Wind-Excited Oscillations of Tall Stacks," June 10th, 1955, pages* 806–808).

FIGS. 11 and 12 show typical results at two different traverse positions for a range of speeds. Maximum errors are seen to coincide with the largest amplitudes, in agreement with the results obtained on the vibration rig (Fig. 1). The modification of the vortex shedding frequency by the cylinder oscillations is shown in the divergence between the measured frequency of the cylinder and the calculated vortex frequency. As mentioned later, the latter has been calculated using data from recent tests on stationary cylinders.[15] The results of traverse readings at different test section velocities are summarised in Figs. 13 and 14. In all tests the following uniform pattern of vibration behaviour was noted.

For short free lengths of instrument, vibration could be felt by touch, no effects being apparent in the readings. Once noise was generated, visual flutter set in sporadically and deviations in readings were observed for the first time. At this stage the amplitude could not reliably be measured. With greater amplitudes the errors increased rapidly, the maxima of the two invariably coinciding. These ranges are marked in Fig. 13 for the readings taken at a velocity of 20ft per second. In Fig. 14 the maximum deviations observed have been plotted for various traverse positions and speeds in the test section. Visual observation of the flutter, and analysis of high-speed films taken at 3000 frames per second for different cylinder frequencies and amplitudes, showed the frequency of cylinder oscillation and vortex shedding to be the same. The dead water in the immediate downstream vicinity of the cylinder followed its motion, but being unaffected by the restraint due to elastic forces, appeared to extend forward round the cylinder towards the front stagnation point. This motion opposing the oncoming flow seemed to reach its maximum when the cylinder was already moving in the opposite direction towards the central position. In the smoke pictures (Fig. 4) the effect of a general flow is absent and the secondary fluid motion can develop into streaming in the plane of vibration.

A comparison of results with those obtained from the smaller brass cylinder in the towing tank shows that vibration in the tunnel occurred at higher speeds and that the resulting errors were smaller. This may be explained by the increased flexural rigidity of the larger diameter steel cylinder, and the effect of the different end fixing. With the same vibration energy supplied by the flow, perfect rigid end fixing and perfect elasticity of the cylinder would result in the largest obtainable amplitude. If, however, part of this energy is dissipated in the support or transmitted to the outside in the form of sound or vibration, the amplitude and thus the resulting suction pressure will be reduced.

The flutter effects on the performance of the pitot static probe (Fig. 10) were investigated during the initial phase of the work, when the instrument was used in the calibration of the tunnel contracting nozzle. The speed range extended to 40ft per second and each traverse consisted of twenty measurements in the test section. Strong audible and visible vibration occurred at large overhangs and for speeds in excess of 20ft per second. No effects were noted, except for isolated small fluctuations in the probe total pressure readings of the order of ±1 per cent of the velocity pressure when traversing very near to the opposite wall. The static pressure readings agreed throughout with the contraction throat readings. Nowhere could an increase in amplitude comparable to that of the cylinder vibration be observed.

PITOT CYLINDER FLUTTER CALCULATIONS

One objective of this investigation was the calculation of the critical speed or Reynolds number at which a given instrument was likely to be affected by vibration. If a prediction of this kind were possible, it would lend itself equally well to the selection of probe dimensions for vibration-free performance under known conditions of operation. The uncertainty introduced in all calculations by the unknown probe end-fixing conditions justifies a simplified treatment. The end fixing was assumed to be perfectly rigid, and the vibration treated as linear, as well as unforced and undamped for which a solution is available.[16] Account was taken, however, of the virtual mass due to motion in water. In fact, a pitot cylinder represents a system with an infinitely large number of degrees of freedom and the motion is both forced and damped. The effect of damping

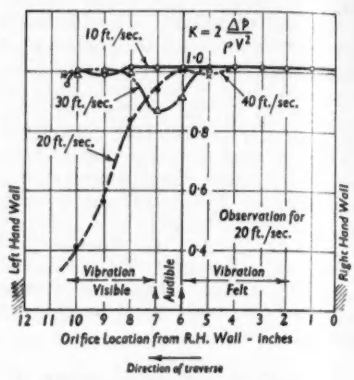


Fig. 13—Traverse readings of 0·5in diameter silver steel pitot cylinder. Orifice distance from tip 1·5in

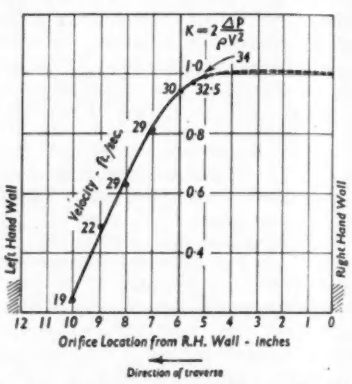


Fig. 14—Maximum deviation due to vibration

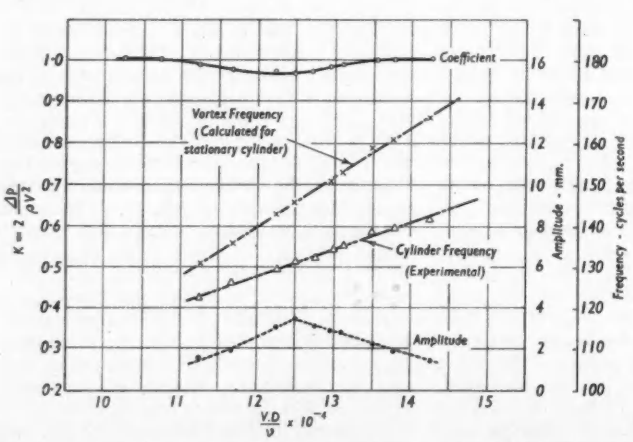


Fig. 11—Pitot cylinder tip, 7·0in from right-hand wall, tunnel section 12in diameter

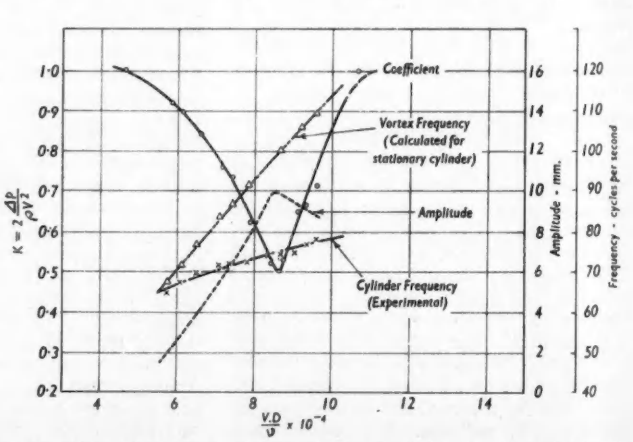


Fig. 12—Pitot cylinder tip, 10·5in from right-hand wall, tunnel section 12in diameter

* Fluid Mechanics Division, Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

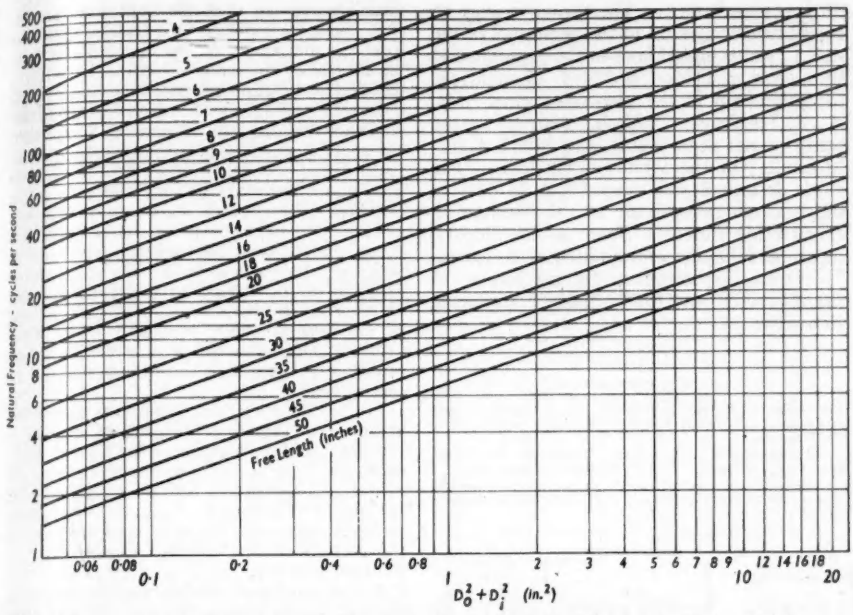

Natural Frequency - cycles per second
Free Length (inches)
$D_o^2+D_i^2$ (in.^{2})
Multiplication factor for steel, $F_{ST}=1\cdot6$.
Multiplication factor for double-end supported cylinders, $F_{DE}=4\cdot6$.

Fig. 15—Natural frequency of a cantilevered brass cylinder

on the cylinder frequency may be assumed to be negligibly small.

The natural frequency of a cantilever beam for the fundamental mode of vibration is :

$$f=0\cdot56\times\frac{1}{L^2}\times\sqrt{\frac{E.I}{m_c}}\text{ (c/s)} \quad . \quad . \quad (1)$$

where L=free length, $E.I$=flexural rigidity, and m_c=mass per unit length. For a circular cross section :

$$f=0\cdot56\times\frac{1}{L^2}\times\sqrt{\frac{E}{\rho}}\sqrt{0\cdot0625\times(D_o^2+D_i^2)}\text{ (c/s)} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

E=modulus of elasticity, ρ=density, D_o, D_i=outer and inner cylinder diameter. For brass this becomes

$$f=1\cdot71\times10^4\times\frac{1}{L^2}\times\sqrt{D_o^2+D_i^2}\text{ (c/s)} \quad . \quad (3)$$

which is plotted in Fig. 15. To extend the use of the graph to steel and to double-end-supported cylinders, the frequency has to be multiplied by $F_{St.}=1.6$ and $F_{D.E.}=4.6$, respectively. The factor $F_{D.E.}$ was obtained by making the constant in equation (1) 2·57, the arithmetic mean of the constants for the simple and fixed ended beam respectively.

The increase in resistance due to the non-uniform motion of the cylinder through water is accounted for by addition of a virtual mass. Thus, for vibration in water the frequency becomes :

$$f_W=0\cdot56\times\frac{1}{L^2}\times\sqrt{\frac{E.I}{m_e+m_W}}\text{ (c/s)} \quad . \quad (4)$$

where m_W=mass of water additionally "vibrated" per unit length. Equation (4) may be written :

$$f_W=f\times\sqrt{\frac{1}{1+\frac{m_W}{m_e}}}=f\times\sqrt{\frac{1}{1+k}}\text{ (c/s)} \quad . \quad (5)$$

where $\sqrt{\frac{1}{1+k}}=F_M$ has been termed the virtual mass factor, k being the ratio of added mass to displaced cylinder mass.

Experimental determination of the virtual mass is difficult, and little data is available. For a cantilevered beam, no data could be found. Tests were carried out in the test section of the water tunnel (Fig. 6), using a 25 lb magnetic vibrator to oscillate the pitot cylinder in air and also submerged in water. For twenty readings at different traverse positions a value of $F_M\sim0\cdot95$ was obtained.

Since the equipment used lacked refinement, it was desirable to check this result, at least comparatively. The graph of the virtual mass factor F_M (Fig. 16) was therefore based on the results given for free cylinders.[17] In that case, the additional mass and thus k will be larger than for the cantilevered beam. If used for the prediction of vibration effects, the result is therefore likely to err on the safe side since equation (5) will indicate a lower frequency and thus speed than the true critical one for the cantilevered pitot cylinder. As will be seen from Fig. 16, the virtual mass factor is also practically constant for the free cylinder results, and for the whole of the practical range of lengths and diameters $F_M\sim0\cdot71$.

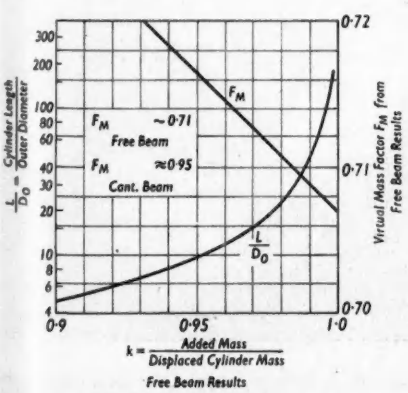

$\frac{L}{D_o}$ = Cylinder Length / Outer Diameter
F_M ~0·71 Free Beam
F_M ≈0·95 Cont. Beam
Virtual Mass Factor F_M from Free Beam Results
$k=\frac{\text{Added Mass}}{\text{Displaced Cylinder Mass}}$
Free Beam Results

Fig. 16—Virtual mass factor

The critical Reynolds number has been calculated, using the F_M-values for both free and cantilevered cylinders, by assuming the critical condition to occur for coincidence of the cylinder and vortex frequency. The latter was calculated from :

$$f_V=0\cdot19\times\frac{V}{D_o} \quad . \quad . \quad . \quad . \quad (6)$$

where V=mean flow velocity and the Strouhal number $S=0\cdot19$ was taken from reference.[16] The critical velocity or Reynolds number follows by equating (5) and (6). Results are tabulated below, giving the nominal traverse position, the true free cantilever length to the recessed probe support and the critical Reynolds number for both F_M-values. The maximum deviations are also listed, and the Reynolds numbers at which they occurred. The errors at the predicted speeds are given in per cent of the dynamic pressure. As expected, when using the virtual mass factor for free cylinders, results are on the safe side, i.e. up to the critical speeds predicted probe readings are still unaffected by flutter. When using the experimental value $F_M\sim0\cdot95$ for the cantilevered cylinder, results for the largest free instrument lengths are already to some extent in error due to vibration. This would suggest the use of a virtual mass factor F_M less than 0·95, but greater than 0·71 in the determination of the critical Reynolds number. It must be remembered that these few results were obtained by making a number of limiting assumptions, and that any calculation of this kind is only approximate. Fig. 10 may be used when selecting probe dimensions for a given application. Extension to pitot static probes with round struts is not considered here, but could be introduced by estimating the effect of the instrument head, and expressing this in terms of additional cylinder length.

Conclusions

Probe instruments of the cantilevered cylinder type are strongly affected by vibration resulting from vortex shedding. The ensuing pressure reading errors are caused by a secondary flow generated by the vibration, and were found to increase with frequency and vary with the square of the amplitude. Tip shape effects were noted. Pitot static probes with round struts are less affected since the pressure orifices are removed from the vicinity of the stem and the instrument head tends to damp the oscillation and reduce the amplitude. Instruments with aerofoil struts were found to be unaffected by vibration when aligned with the flow, due to the damping of the lateral motion by the aerofoil strut which reduces

Orifice position from wall (inches)	Free instrument length (inches)	f_W F.C. calculated (c/s)	f_W C.C. calculated (c/s)	$R_{e_{crit}}\times10^4$ F.C.	Measured error F.C. $\left(\%\frac{\rho V^2}{2}\right)$	$R_{e_{crit}}\times10^4$ C.C.	Measured error C.C. $\left(\%\frac{\rho V^2}{2}\right)$	R_e for maximum experimental error $\times10^4$	Maximum measured error $\left(\%\frac{\rho V^2}{2}\right)$
5·5	12·3	75	102	6·4	0	8·7	0	12·5	3
6	12·8	69	94	5·9	0	8·1	0	11·7	5
7	13·8	62·5	84·5	5·4	0	7·3	0	11·5	18
8	14·8	53·5	72·5	4·6	0	6·2	3	11·4	36
9	15·8	47·5	64·5	4·1	0	5·5	5·0	8·3	50
10	16·8	42	57	3·6	0	4·9	12·5	7·5	75

F.C.=Calculated with virtual mass factor for free cylinders $F_M\sim0\cdot71$
C.C.=Calculated with virtual mass factor for cantilevered cylinders $F_M\sim0\cdot95$

Calculated frequencies determine critical Reynolds numbers, for which errors are found from experimental results.

the amplitude to negligible magnitudes.

In all tests, errors became noticeable in that part of the speed range where sound was first generated, and increased with increasing amplitude after the initial vibration noise had ceased. The effect of end fixing is marked, and it was found that the magnitude of the largest amplitudes and thus the errors in the probe readings were reduced through energy dissipation in the probe support. Graphs are presented which permit the approximate determination of the critical speed at which vibration is likely to affect pitot cylinder readings, and these may be used in the design of a probe for given conditions of operation. The use of faired support struts is recommended for all applications where reasonable alignment with the flow is possible, and sealing problems can be overcome.

ACKNOWLEDGMENTS

Permission given by the Superintendent, A.R.L., to use the 12in water tunnel is gratefully acknowledged. The writer wishes to express his obligation to the personnel of the A.R.L. water tunnel, and of the experimental ship tank at Denny Brothers, Dumbarton, for their help in the respective tests. Mr. A. B. Stephenson, A.R.L., assisted in the water tunnel experiments, and Mr. J. Kane, M.E.R.L., in the vibration rig tests. The work described was carried out as part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. This paper is published by permission of the Director of Mechanical Engineering Research.

REFERENCES

[16] Delany, N. K., and Sorensen, N. E. : "Low-Speed Drag of Cylinders of Various Shapes." *N.A.C.A. Technical Note No.* 3038, 1953.

[17] Timoshenko, S. : *Vibration Problems in Engineering.* Second edition, page 87. (D. van Nostrand Company, Inc.)

[17] Stelson, T. E., and Mavis, F. T. : "Virtual Mass and Acceleration in Fluids." *Proc. A.S.C.E.*, 1955, Vol. 81, Separate No. 670.

Automatic Co-ordinate Setting on a Horizontal Boring Machine

An automatic co-ordinate setter for jig boring machines has been developed by the British Thomson-Houston Company, Ltd., Rugby, and is described here. It is designed to reduce costs by speeding-up production and eliminating the need for jigs. Movement of the table and spindle slides to any desired position is effected through servo mechanisms by setting up the required co-ordinates on dials on a control desk. For longer runs the setting can be done by a punched card reader on the control desk. For each ordinate there are six dials giving displacements to six significant figures and the system is stated to be accurate to ±0·0002*in.*

ABOUT two years ago the British Thomson-Houston Company, Ltd., Rugby, started work on the development of automatic co-ordinate setting for boring machines. The first commercial application of this work was completed several months ago, when a Kearns No. 0 planer table horizontal boring machine fitted with B.T.H. automatic co-ordinate setting controls was installed in the Leicester factory of the British United Shoe Machinery Company, Ltd. A general view of the installation is given in Fig. 1.

Briefly, the co-ordinate setter consists of servo-mechanisms operating the table and spindle slides of the machine which have traverses of 57in and 42in respectively. The slides can be moved to any position by setting up the co-ordinates on dials, which are to be seen on the face of the control desk in Figs. 1 and 2. Six dials and clearly displayed figures are provided for each of the two ordinates, to set up any required displacement from a predetermined datum. The "dial-in" method of setting is appropriate to very short run production and toolroom class of work generally, and results in marked time saving as the operator is relieved of the duty of reading and adjusting to finely graduated scales, or handling of length bars. For longer runs the slides can be set up by a card reader, which is also on the operator's control desk, and is shown in more detail in Fig. 2. One punched card is used per hole centre which enables operator instructions to be added where appropriate ; thus a deck of cards must be prepared per workpiece. Automatic clamping of the slides is provided when the desired co-ordinate position is reached.

The blueprint (which may not be required on the factory floor so far as the boring operations are concerned) will show dimensions with respect to two datum lines convenient to the particular workpiece. To simplify setting up procedures, the co-ordinate setter includes means for changing quickly the datum of measurement for each traverse. The wide speed range servo-mechanisms necessary for co-ordinate setting provide a convenient feed drive for milling operations, suitable controls for which are provided. Basically, the machine tool is a normal Kearns horizontal borer with the addition of the power servos already mentioned and a built-in measuring system for automatic control.

PRINCIPLES OF OPERATION

The card reader unit serves to shift the hand setting dials, thereby giving a check, if necessary, on the accuracy of card reading. Identical servo-systems are used for both traverses and it is therefore sufficient to describe operation from the dial shafts on the operator's desk, to the control of one motion. Referring to Fig. 3, the electrical measuring system on the machine tool table comprises a rigid measuring bar accurately divided into 1in units by holes spaced 1in apart along its length. An electromagnetic sensing head, mounted on the bed of the machine tool co-operates with the bar and provides an electrical misalignment signal to the control system. The electromagnetic unit is capable of being shifted by a micrometer screw and an accurate instrument servo through any displacement up to 1in. Thus, the measuring bar may be regarded as providing accurate measurement of the integral inches part of a required co-ordinate shift, while the decimal part is accommodated by accurately controlled shift of the sensing head.

In the following description the controlling action is described as a sequence, though in practice certain motions take place simultaneously. The action of setting up the required co-ordinate dimension on the six dials causes the "input" synchros S_1, S_2, S_3, S_4 to be rotated, giving misalignment signals in co-operation with the corresponding "output" synchros T_1, T_2, T_3, T_4 respectively.

The decimal part of the required dimension is now represented by rotation of the shafts S_2, S_3, S_4, and this rotation causes the servo-amplifier A to operate the motor M until the synchros S_2-T_2, S_3-T_3, and S_4-T_4 are in alignment. While it is effecting this alignment the motor M also rotates an accurate micrometer screw, through an instrument-quality gearbox and thus shifts the electromagnetic head through the required decimal dimension.

The integral part of the desired co-ordinate (with a contribution from the decimal part) gives a rotation of synchro S_1 which is interconnected with synchro T_1 geared to the lead-screw. A misalignment signal from S_1-T_1 controls servo-amplifier C and, via the motor M_2, brings the table to within about 0·2in of the desired position, the traverse speed being maintained at about 120in per minute until the last inch or so of travel is reached, after which the speed is progressively reduced. Control of the motor M_2 is now transferred (via servo-amplifier B) to the electromagnetic head. The control signal from the latter drives M_2 until the poles of the magnetic head are aligned opposite

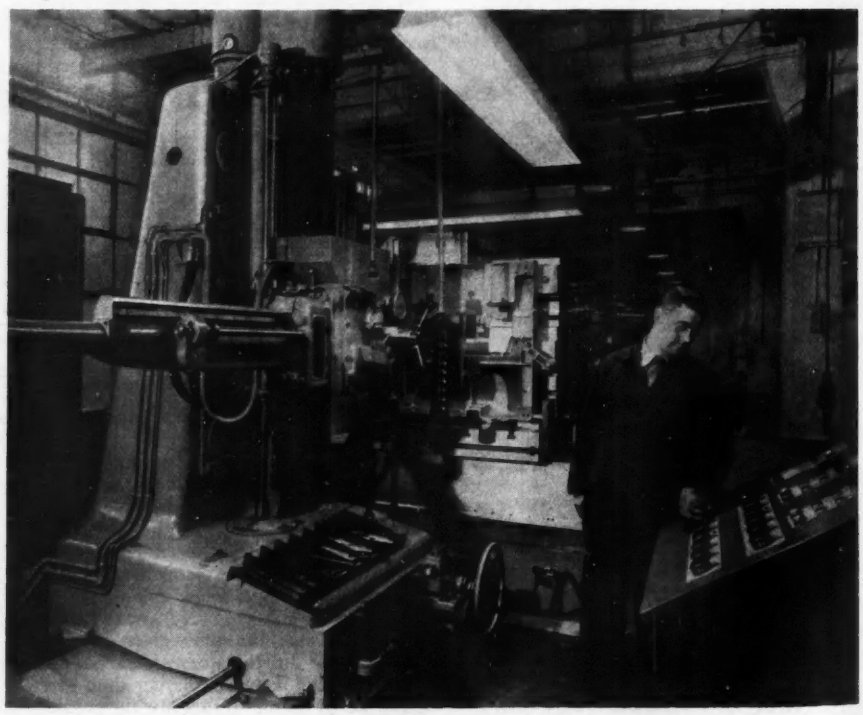


Fig. 1—Horizontal boring machine equipped with automatic co-ordinate setting. The movements of the table and spindle slides is effected by servo-mechanisms in response to co-ordinates set up on dials or on punched cards in the control desk on the right

the nearest hole in the bar, under which conditions the error signal from the magnetic head becomes zero.

During the approach to alignment under the control of the electromagnetic head, a temporary misalignment signal is injected into amplifier *B*, whereby the table travels to a " false alignment " position, approximately 0·020in from true alignment. The temporary signal is then automatically removed and thus the final approach to alignment is always from the same direction. The error signal from the magnetic head is proportional to the displacement from the desired position, and reverses in phase for an error in the opposite direction. This provision permits the final approach to alignment to be made under conditions of controlled velocity and retardation of the table, so that the manner of stopping is predetermined by the electronic circuits, and not by extraneous conditions such as viscosity of lubricants, table loading, &c.

After the setting of the digit dials—by hand or card—the automatic setting of both co-ordinates on the machine tool is initiated by push-buttons, and the sequence ends by the automatic clamping of both motions.

Detail of the Measuring System

The measuring bar (Fig. 4) is of heavy construction in a special steel and carries the " inch units " which are identical blocks with a ¼in diameter hole in the face ; to present a smooth face the holes are filled with brass inserts. The bar is set up in a temperature-controlled measuring room so that the reference holes are 1·000in ±0·0002in apart. A final screwdriver adjustment is available and, through the medium of an asymetrical steel slug in the bar, it allows the effective magnetic position of each hole to be shifted up to ±0·0005in. The final adjustment is preferably left until the bar is in position on the machine tool.

The electromagnetic head is essentially a differential arrangement of two transformers, the magnetic circuits of which are completed by that part of the measuring bar which faces the head.

Since the construction of the head is symmetrical it is free of changes caused by tempera-

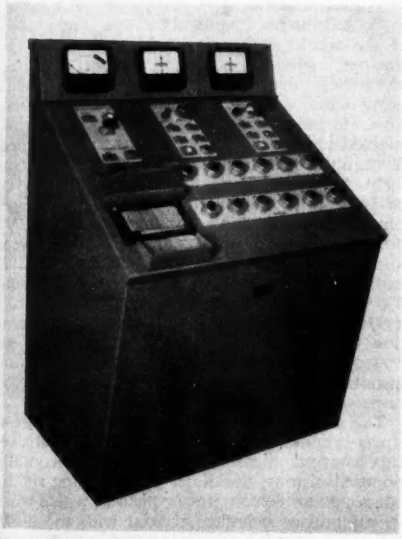


Fig. 2—Control desk. The required position of the table and spindle slides is set up by adjusting the control knobs on the right or, for longer runs, by feeding in punched cards on the left

ture, supply voltage and frequency variations, and stray magnetic fields. The gap between the magnetic head and bar is not critical. The sensitivity of the head is such that it is capable of delivering a sufficient voltage to operate the servos with 20 micro-inches misalignment from the magnetic centre of one of the reference holes in the bar. Oiled felt pad wipers are carried on the head to clean the face of the measuring bar.

As previously stated, the sensing unit in the head is shifted by the decimal part of the co-ordinate desired ; accordingly it is carried on a short,

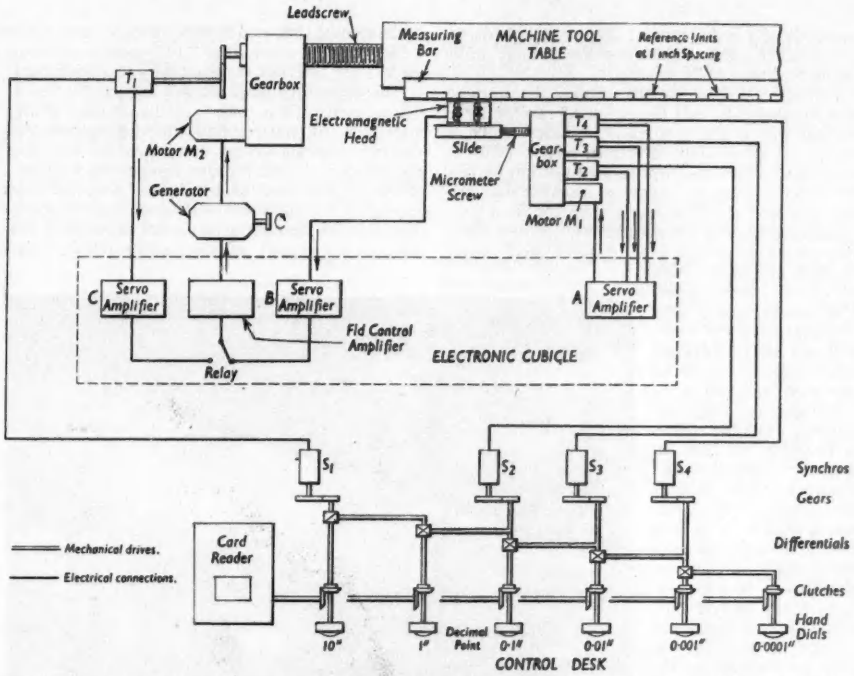


Fig. 3—Schematic diagram of automatic setting of table on a horizontal boring machine. A similar scheme controls the spindle position

accurately-made slide, parallel with the measuring bar. A high-accuracy electronic servo effects the positioning through the medium of a gearbox and micrometer screw. As shown in Fig. 3, coarse, fine and very fine synchro data units are used to attain high accuracy. While reliance is placed on the accuracy of a micrometer screw to shift the electromagnetic head, it should be appreciated that the only force on the screw is that to move a mass of a few ounces in carefully made slides.

Operator's Control Desk

The control desk (Fig. 2) may be installed at the most convenient position to suit the machine tool operator, since connection to the rest of the system is by the electrical control wiring only. Appreciable space on the desk is allocated to the digit set-up dials, to give clearly displayed figures and conveniently sized and disposed set-up knobs. Detent action on the dial shafts gives positive location for each of the ten decimal positions of each dial.

From Fig. 3 it will be seen that the synchros S_1, S_2, &c., are not operated directly by the dials, but through differential gears and other gearing of appropriately chosen ratios. The differentials serve to add one-tenth of the rotation of any dial to that of the shaft behind the adjacent dial on its left-hand side. Briefly, this is necessary for the following reasons.

(1) In the coarse, fine and very fine data transmission between the desk and the micrometer servo, there is a fixed relationship between the rotors of T_2, T_3 and T_4 through a normal gear train. The same apparent relationship must, therefore, hold between the shafts of S_2, S_3 and S_4 so that alignment S_2 to T_2, S_3 to T_3 and S_4 to T_4 may take place simultaneously and unambiguously wherever the dials are set. It would not be satisfactory to gear the dials together directly ; with such an arrangement the right-hand dial would need to make a thousand revolutions for every inch change of setting, which would be slow and inconvenient. It is preferable that, to the operator, the dials should appear to be independent.

(2) Differential coupling is also used to the left of the decimal point, to ensure that no ambiguity arises if the input dials are changed from, say, 12·0000 to 12·9999. This change would cause the electromagnetic head to be moved very nearly into alignment with the thirteenth unit on the measuring bar ; it must not, however, be aligned with this unit, but with the twelfth. Therefore, the synchro S_1 is rotated by an amount which corresponds approximately to 0·9999in and through the main servo-motor M_2 brings the table nearly to the correct position, as described previously.

Control Desk

Card Reader.—The card reader is to be seen on the left-hand side of the desk in Fig. 2. Standard size business machine cards are used, but made of a material which is impervious to oil. They can be prepared for use by means of a simple hand punch. Identification and operator's instructions are written or printed on each card, one card being used for each pair of co-ordinates. A card for 12·3456in, 21·1968in is shown in Fig. 5.

In operation a card is taken from a stack and placed on the carriage. A " start " push button is pressed, which causes the carriage with the card on it to be drawn into the reader. Simultaneously, the dials are automatically returned to their zero positions. The carriage then reverses its direction of movement and brush contacts are lowered on to the card. As the card is returned to its start position the dials are rotated in unison. The brushes can complete electric circuits through the holes in the card and when any one brush makes contact the appropriate dial is disengaged from the driving mechanism and is left accurately positioned by means of a detent wheel and spring-loaded arm.

Auxiliary Controls.—In addition to automatic co-ordinate setting, milling feeds are available, and advantage is taken of the servo system in providing continuous adjustment of feeds from ½in to 10in per minute. Three meters are mounted on the desk, one indicating spindle horsepower and the other two indicating when coincidence has been achieved between the machine tool slide positions and the numbers set up at the desk. These meters are used principally for setting the datum for measurement, but may also be used as a means of checking that correct positioning has been achieved.

The Machine Tool

The machine is constructed on the well-known Kearns unit principle and consists of a main bed 10ft long carrying a table 3ft by 6ft. This main table, on which is mounted a cellular-constructed revolving table 3ft square, has a total transverse traverse of 4ft 9in. Because of the length of the main bed, the table is fully supported throughout the full length of this traverse.

Built into the main table is an easy-revolving mechanism for lifting the revolving table, to reduce the effort required for rotation. At both sides and at right angles to the main bed are auxiliary beds, each 4ft wide across the ways and carrying the upright and boring stay bases respectively. These bases can be traversed

longitudinally a distance of 2ft on their beds to give a total distance between the spindle nose and boring stay of 7ft 6in.

The upright base, which carries the upright and spindle slide, can be traversed rapidly by a built-in stator and rotor unit, besides which a full range of sixteen reversible power feeds is available. The well-proportioned upright carries the spindle slide in which is incorporated the change speed and feed mechanism for the longitudinal traverse of the spindle and upright base. The travelling spindle is of nitrided steel superfinished and bored with a No. 5 Morse taper. The spindle slides in a nitrided cast iron bush, within a sleeve of forged steel, which rotates in precision ball and roller bearings. A range of sixteen reversible speeds is available to the 3in diameter spindle and these are selected by only two levers. The 5 h.p. stator and rotor unit is mounted in the base of the upright and drives the change speed gearbox in the spindle slide through a constant-speed vertical shaft. On the feed mechanism to the longitudinal traverses of the spindle and upright base two complete ranges are available. One is driven from the spindle sleeve and gives eight feeds in cuts per inch. The other is driven from the first motion drive shaft and gives eight feeds, independent of the spindle speed, in inches per minute. The main drive motor is controlled by an automatic contactor direct-on-line starting panel housed in the back of the upright.

With a view to using the accuracy available in the electronic co-ordinate setting system, and to maintaining it throughout the life of the machine, the transverse movement of the main table is obtained by mounting the gearbox direct on the end of the main bed, thus giving a direct drive via a constant-length shaft and two large-diameter coupled worms, to a segmental phosphor-bronze nut, attached to the main table. This gearbox, besides providing the drive for automatic positioning, gives an infinitely variable range of feeds from ½in to 10in per minute, and rapid traverse at a rate of 120in per minute.

Special attention has been given to the lubrication system. Table lubrication is provided by a motor-driven oil pump with independent feed regulators to the various points. A number of large-sectioned interconnected oil grooves, at right angles to the line of travel, are machined in the main table. The motor-driven oil pump is connected with the control pendant and operates automatically whenever the table is traversed.

The vertical movement of the spindle slide is also directly under the control of a gearbox which is mounted on the top of the upright and directly coupled to a large diameter vertical screw. This box provides the drive for automatic positioning, together with the range of feeds and rapid traverse motion similar to the main table.

Again, exceptionally long, narrow guides are used on the spindle slide. Lubrication of the spindle slide is like that of the table, the lubricant being supplied by a separate hand-operated pump. Special care has been taken with the supports for the measuring bars and electromagnetic detector heads, which are used for automatically positioning the vertical adjustment of the spindle slide and transverse movement of the table. In both cases large " H "-section cast iron girders are used for carrying the measuring bars.

The control pendant carries ten push buttons. Three control the main spindle motor, giving start/forward, start/reverse and stop, an electrodynamic braking system being used for stopping the spindle. Three buttons control the inch/forward, inch/reverse to transverse movement of the table and the start of automatic positioning. Three more buttons give similar control to the vertical movement of the spindle slide. The remaining button stops the spindle slide and table movement.

Fig. 4—Measuring bar which determines the inch integers in position setting. Each inch unit in the bar is an identical block with a ½in diameter hole filled with a brass insert, the hole centres being 1in ±0·0002in apart

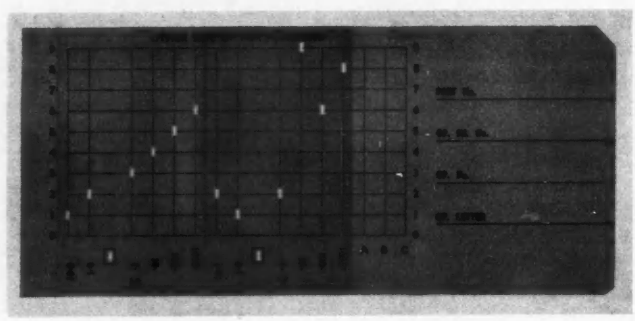


Fig. 5—Typical card punched for a horizontal setting of 12·3456in and a vertical setting of 21·2968in

To ensure the holding of a slide which has reached the required position, hydraulic clamps automatically operate on the spindle slide, table and boring stay bearing. The hydraulic clamp is carried in a steel cabinet alongside the machine. Solenoid-operated valves control the oil circuit which operates the hydraulic cylinders. Maximum clamping is obtained by the use of a wedge, lined and bushed by plates of P.T.F.E. material. Two of these clamps are provided on the spindle slide and one each on the transverse movement of the table and vertical adjustment of the boring stay bearing.

To ensure that no distortion takes place on the main sliding surfaces, the hydraulic locks operate through a friction material with independent strips attached to the main casting. The vertical adjustment of the spindle slide and boring stay bearing are synchronised mechanically but, if required, the boring stay bearing can be realigned vertically through a wormwheel mechanism operating on the screw nut.

Performance

The accuracy required for the installation described here is ±0·0005in, but ±0·0002in is achieved in practice. By using very accurate micrometer screws for positioning the detecting heads and by taking advantage of the facility for fine adjustment of the 1in units on the measuring bar, the equipment is capable of ±0·0001in. The measuring bars are set at 68 deg. Fah. and have the same temperature coefficient as cast iron. Consequently, variations of shop temperature do not produce discernible errors when working on cast iron.

Two typical operations can be quoted to indicate the saving in time obtainable with the B.T.H. automatic positioning system on the machine described above, as tabulated here.

(1) Operations : 6 holes drilled and counterbored. 9 holes drilled and tapped. 11 holes drilled.	
Time previously required for marking out and drilling	4 h 14 min
Time required for same operations with automatic positioning	2 h 17 min
(2) Operations : 9 holes drilled and counterbored. 7 holes drilled and tapped. 8 holes spot-faced and drilled.	
Time previously required for marking out and drilling	4 h 47 min
Time required for same operations with automatic positioning	2 h 34 min

Manufacture of the Free-Piston Engine

At a meeting held on Monday, March 26th, Mr. L. W. Robson, the chairman of Associated British Engineering, Ltd., announced the formation of a new company, namely, the Free Piston Engine Company, Ltd., within the group, which consists of the Bergius Company, Ltd., British Polar Engines, Ltd., Henry Meadows, Ltd., A. C. Morrison (Engineers), Ltd., the Parsons Engineering Company, Ltd., and H. Widdop and Co., Ltd. This development follows the agreement signed with Alan Muntz and Co., Ltd., whereby the parent company acquired certain rights to the Pescara free-piston patents. The sub-licences to manufacture relate to the United Kingdom, British Commonwealth, as at 1937, and Egypt, together with certain other territories covered under reciprocal arrangements with the French licensees. All applications are provided for with the exception of machinery for tugs, trawlers and whalecatchers, which come under earlier agreements made with C. D. Holmes and Co., Ltd., and Smith's Dock Company, Ltd. Headquarters of the new company, which has been formed for the commercial exploitation of the above agreements, will be at the Park Lane Works of Henry Meadows, Ltd., at Wolverhampton.

An exhaustive investigation was undertaken of the whole engineering field covered by the free-piston engine system and a report prepared on current progress and the practical results being obtained over a wide range of applications. This, together with expert technical advice, enabled certain broad conclusions to be reached favourable to making a decision regarding agreement to manufacture. The practical survey covered forty installations, using eighty gas generators with a total running time of 150,000 hours. A wide diversity of applications were inspected and included the 1000 h.p. Renault experimental locomotive which has completed 130,000 miles on regular passenger train service ; a 600kW generating set which has been in operation for two years ; a 6000kW generator set powered by eight gas generators ; and two marine installations of 1800 s.h.p. which have completed respectively 10,000 and 7500 hours at sea.

The free-piston gas generator consists of a single-cylinder, opposed-piston, two-stroke, supercharged diesel engine, with horizontally opposed pistons, the diesel pistons being rigidly connected to the compressor pistons, which work in compressor cylinders coaxial with the diesel cylinders. Air for scavenging and supercharging is delivered by the compressor cylinders and the diesel exhaust is used to drive a gas turbine. Two sizes of gas generator are available for immediate production, the S.I.G.M.A. " GS–34 " and the Muntz " C.S.–75," of which the main particulars are given in the following table :—

Item	" GS–34 "	" C.S.–75 "
Engine cylinder bore, inches	13·4	7·5
Compressor cylinder bore, inches ...	35·4	20·75
Overall length, feet	13·75	7·5
Stroke at continuous maximum rating (C.M.R.), inches	2×17·4	2×9·5
Oscillations at C.M.R. (cycles/min) ...	570	1000
Gas temperature at C.M.R., deg. Cent.	437	460
Gas horsepower at C.M.R....	1250	420
Thermal efficiency into gas, per cent ...	43	42
Specific fuel consumption, lb/gas h.p./hr	0·320	0·325
Weight, tons	8·0	2·25

Wadi Tharthar Flood Protection Project in Iraq

Two large flood protection schemes in Iraq, in which British civil engineers have played a leading part, were due to be inaugurated by King Faisal this week—the Wadi Tharthar scheme on April 2nd and the Habbaniyah scheme on April 5th. The Wadi Tharthar scheme is described in this article.

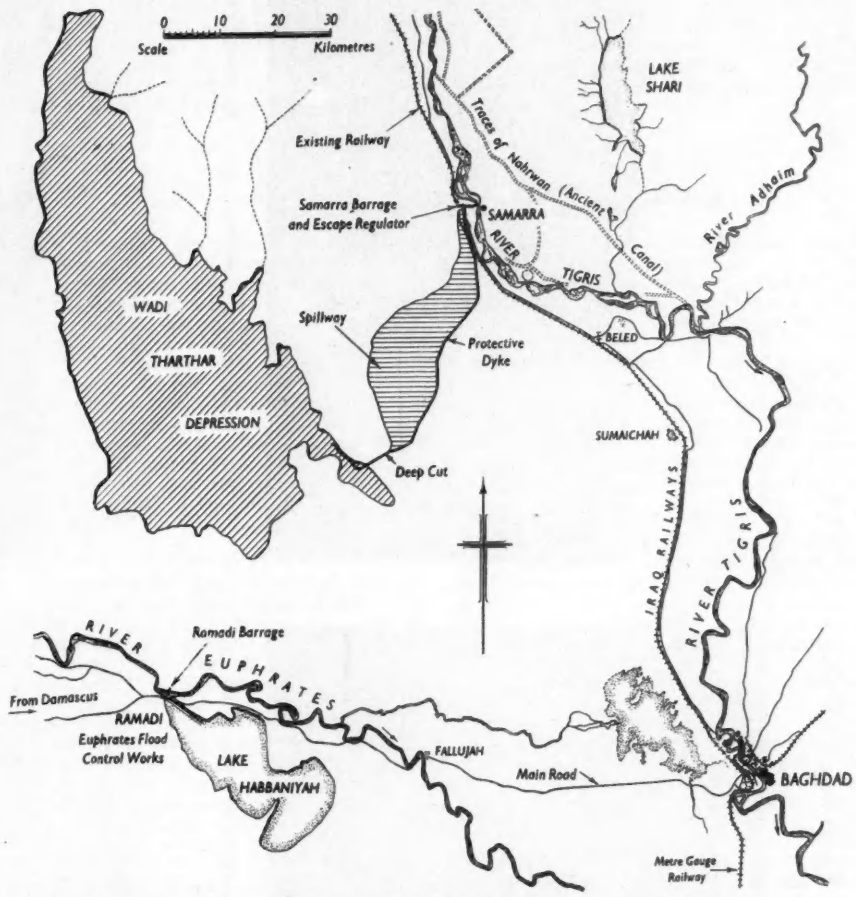
THE Wadi Tharthar Project, some 60 miles north-west of Baghdad, is perhaps unique in its conception.* It was first put forward by Sir William Willcocks in about 1908, as a means of preventing the disastrous floods which caused so much loss every year to the agricultural areas in the south. It has, however, grown considerably since then, with the increasing wealth of Iraq, and now provides facilities for a future hydro-electric power station, as well as convenient access across the River Tigris to the town of Samarra, which 800 years ago was the capital of Mesopotamia and stretched for many miles along the river, and the headworks of a proposed canal. The total cost of the scheme will be about I.D.15,000,000.

The original idea had always been to construct a barrage across the river, thus raising its level sufficiently to command the waste desert land on the west bank and cause the flood waters to flow to the Wadi Tharthar Depression, about 100km distant, their return to the river being prevented by a protective dyke, 53km long. This layout is clearly shown in the accompanying map. The depression is a strange geological fact, the origin of which is still in dispute ; its bottom is 70m below the surrounding ground, and is just below sea level ; it is of irregular shape, but is considerably larger than the Dead Sea, and if full to the level of +60m would contain 67 milliard cubic metres of water.

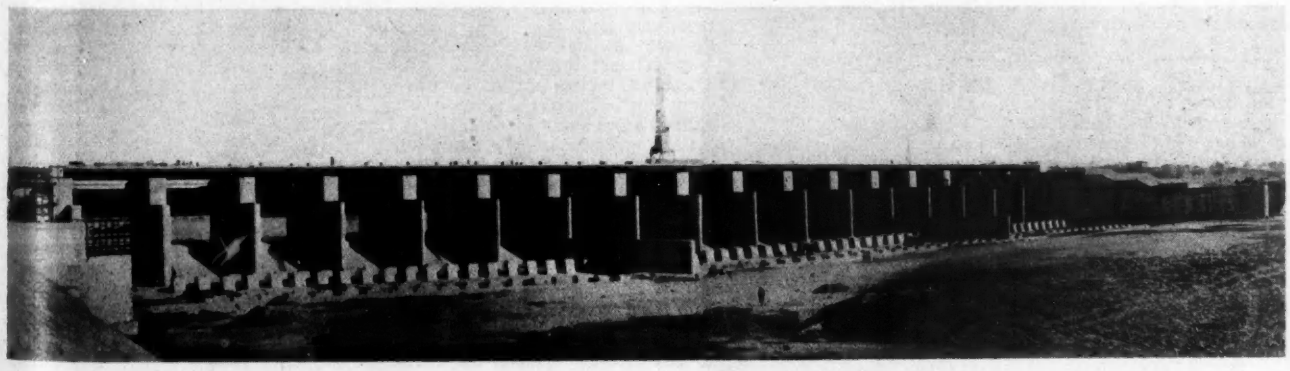
The Government of Iraq decided to proceed with the project in 1949, and its irrigation department requested their consultants, Messrs. Coode and Partners, to prepare the designs and contract documents. Subsequently, the Development Board took over the responsibilities of the irrigation department in connection with design and construction.

A contract for the protective dyke and the escape channel through the hillocks surrounding the depression was let to Balfour, Beatty and Co., Ltd., in 1951. The work comprised the construction of a dyke 53km long, leading to an escape channel 5·7km long, 150m wide at the bottom and up to 17m deep. The materials for the dyke were to be obtained by excavating a channel alongside which would carry up to a 500 cumecs discharge, flood waters above which would spread over the surrounding desert to a width of 10km and a depth of about 5m before collecting again to flow through the escape channel, which was designed for a total discharge of 7000 cumecs. The contract involved the shifting of 35,000,000 cubic metres of spoil an average distance of about 100m, the actual turn-round working out at about 1km. After the disastrous floods of 1954, and in view of the country's financial affluence, the Board agreed to increase the capacity of the works so as to divert a flood discharge of 9000 cumecs, and also to embody certain desirable modifications in the design ; and the contract which has now been completed within the original contract time of fifty months has involved the shifting of 40,000,000 cubic metres of earth. It is believed to be the biggest earth-shifting contract that has ever been let. It may be of interest, therefore, to describe briefly this contractor's organisation and the considerable preliminary works which were necessary before the main excavation could be commenced.

Four camps were established in the desert at 20km intervals along the route of the channel, with semi-permanent houses of mud brick, well furnished and air conditioned, together with a club and extensive workshops and stores at the base camp, and huts for over 1500 Iraqis. Married quarters were provided for most married European staff, messes being provided for the remainder and for single men. Food supplies were principally obtained from Baghdad, 75km distant, over desert roads which were quite impassable when it had been raining. The labour problem was considerable, as only about one-eighth of the total strength could be unskilled.



Layout of flood protection works on the Tigris and Wadi Tharthar. The Lake Habbaniyah flood protection works on the Euphrates are also shown



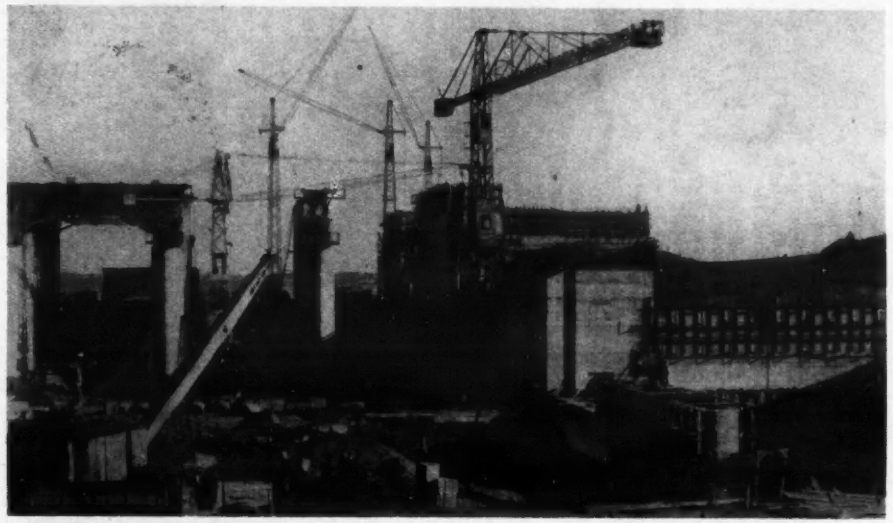
Main barrage of the scheme on the River Tigris. The downstream side of the barrage is shown, and the fish ladder is to the left. There are seventeen openings, each 12m wide and 12m high, to be closed with gates 4·8m high. There is a flow-retarding block across the downstream apron

* The only other scheme working on the same principle is thought to be the Habbaniyah flood relief scheme, which is also shown on the map. The last work of this scheme—Ramadi barrage—was illustrated in THE ENGINEER of January 13th last.

WADI THARTHAR FLOOD PROTECTION WORKS, IRAQ

Barrage and closing bank, with the power station intake under construction in the foreground

Escape regulator under construction. It is to be closed by thirty-six 12m wide sluice gates



Construction of the main barrage, showing, from downstream, work in progress near the left abutment

The completed flood escape channel looking downstream. The channel is 150m wide

Some hundreds of plant drivers and maintenance fitters had to be trained, together with replacements, so that well over a thousand men passed through the school. These men, once trained, were found to be of excellent quality, and no more than twenty Europeans were required for key positions, the remaining staff being Iraqi, with a small number of Indians.

Statistics of Wadi Tharthar Project on the River Tigris

(1 cumec = 35 cusecs)

River Tigris :	
Maximum recorded flood flow at Samarra	14,000 cumecs
Minimum flow	250 cumecs
Wadi Tharthar Depression :	
Length at +60m level	100km
Width at +60m level	38km
Capacity when filled to +60m	67 milliard cubic metres
Area when filled to +60m	2000 square kilometres
Headworks :	
Overall length	4·3km
Barrage :	
Length from left abutment to fish ladder	252m
Number of bays	17
Sill level	+58·0m
Maximum pond level	+69·0m
Downstream bed level	+52·0m
Desired maximum flow	3500 cumecs
Permissible emergency flow	7000 cumecs
Power station intake :	
Length from fish ladder to right abutment	180m
Number of bays	14
Sill level	+58·0m
Regulator :	
Length between abutments	502m
Number of bays	36
Sill level	+63·0m
Maximum pond level	+69·0m
Capacity with downstream level of +68·0m	9000 cumecs
Protective dyke :	
Length	50km
Average height of dyke above surrounding ground	6·5m
Area flooded at a discharge of 9000 cumecs after 24 hours, about	300 square kilometres
Gradient	1 : 10,000
Escape channel through hillocks :	
Length	5·7km
Width at bottom	150m
Maximum depth	17m
Gradient	1 : 2000
Sluice gates :	
Number in barrage	17
Width	12m
Height	4·8m
Maximum head	11m
Number in regulator	36
Width	12m
Height	6·5m
Maximum head	6m

About a hundred heavy earth-moving machines were imported from the United States, mainly Tournapulls, tractors and scrapers, but including a Euclid loader and a fleet of bottom-dump wagons. The nature of the ground was such that it was normally necessary to use a pusher when loading the scrapers. When this plant had reached the site a steady monthly average of 1,000,000 cubic metres of excavation was maintained over long periods. The compaction of the protective bund, especially in the gypseous area where clay was not available, was carried out in full scraper widths, with continuous watering and heavy rolling. This was so successful, we are informed, that on many occasions more than "100 per cent compaction" was obtained.

A second contract was let in February, 1953, for the construction of the barrage and ancillary headworks, to the German firm of Ed. Zublin, A.G., the barrage being sited across the river and 6km upstream of Samarra. There was also at that time a proposal to bridge the river at Samarra, at an estimated cost of I.D.750,000. Immediately after the contract was let proposals were made to change the site of the headworks, the barrage being built in the dry opposite Samarra, and to incorporate any structures necessary to permit the subsequent construction of a low-head hydro-electric power station of an ultimate capacity of 100MW. These structures involved an intake for the power station and a regulator to control the hitherto open channel to the depression comprising twenty-eight 12m openings and various earth embankments, chief amongst which was the bank to be constructed across the River Tigris so as to divert it through the barrage when the latter was sufficiently complete, thus making the proposed new bridge unnecessary.

The barrage as finally constructed consists of seventeen bays, each 12m wide, and 12m high; the gates are 4·80m high; the upper portion of the openings are closed with reinforced concrete diaphragms behind which are housed the counterbalances for the gates; thus, the water can be raised 11m above its original level at the site. The downstream floor is 6m below the upstream floor. At the west end of the barrage is a fish ladder which is suitable for variation of 9m in the upstream water level.

The barrage has a 9m roadway, with two 3m footpaths, carried on reinforced concrete bridges with three main girders, all cast-in-situ. The roadway is designed for the standard Ministry of Transport loading. On the other side of the fish ladder is the power station intake, which now comprises fourteen 10m vents, but is otherwise similar in construction to the barrage. The vents will be closed permanently until they are required for the turbines, which are not at present to be provided.

Some distance to the west is the regulator, which now has the thirty-six openings necessary for a 9000 cumecs discharge, each 12m wide and 7m high; each opening is spanned by two bridges, one to carry a 7m roadway with footpaths, and the other a standard gauge railway, as the floods, when diverted to the depression, will demolish the Baghdad-Mosul-Istanbul main line. Amongst other things it has been necessary to construct 24km of new formation for this line, much of it in cuttings through conglomerate, with many new culverts, and a new station for Samarra, the whole area of which is 6m above the surrounding ground. All the work has had to be carried out without disturbance to the road and rail traffic to Samarra, and the North.

A sub-contract for the fifty-three 12m gates for the barrage and regulator has been placed with Ransomes and Rapier, Ltd. Various phases of the constructional work are illustrated in the accompanying illustrations, and the principal statistics of the scheme are listed in the table. The hydraulic aspects of the main river works of the Wadi Tharthar scheme were investigated with a hydraulic model, and a paper describing these model tests and an investigation into flood probabilities and river hydraulics before and after construction of the barrage was presented on February 7th at the Institution of Civil Engineers; it was entitled "Some Hydraulic Investigations in Connection with the Wadi Tharthar Project, Iraq," and was written by Mr. A. R. Thomas.

"For the Record"

ON account of the dispute in the printing industry, we have been restricted, since February 17th, to "emergency issues" of this journal. The space in each of them has been so severely limited that numerous matters which would ordinarily have had a place in our columns have had, reluctantly, to be put aside. Before us now there is a pile of reports and papers of one kind or another, all of which contain something of interest to engineers and to the engineering and allied industries. To deal fully with all of them now would present some difficulty! But we feel that our readers may find it useful "for the record" if brief reference is made to some of them.

Railway Charges

One matter which is bound to affect industry—at a time when costs are already very high—is the further rise in railway charges, announced by the Minister of Transport and Civil Aviation on March 19th. The Minister prefaced his announcement by explaining that last year's railway strike, coupled with increased costs and wages, added about £30,000,000 to the British Transport Commission's deficit. As a result of further increases in wages and costs the deficit for the current year may be as much as £55,000,000, a figure which would bring the total deficit up to over £100 million.

In view of its statutory duty to pay its way, the Minister said that the Commission had felt bound to come forward with proposals for a substantial increase in charges. The proposals included general increases in freight rates and passenger fares, which were designed to bring in a total of about £37,000,000 in a full year. The Minister then stated that he considered it expedient for regulations to be made authorising increases not exceeding 5 per cent in railway freight, dock and canal charges. He explained that the Transport Commission would make its own announcement about the increases in passenger fares for which it had an existing authority from the Transport Tribunal.

In view of its statutory obligations, the Minister continued, the position must be re-assessed by the Transport Commission in six months' time. During the next six months it was hoped that "this new initiative" would enable the Commission to effect measures leading to improved efficiency and to getting its operations on to a more economic basis, so that a more favourable view could be taken of its financial prospects over the next few years.

Fuel and Power Investment

Another Parliamentary statement of particular interest was that, also on March 19th, by the Minister of Fuel and Power, concerning capital investment in the fuel and power industries. He said that the sum proposed for the coal industry over the calendar year 1956 was £112 million, but the figure actually approved was £107 million. The reduction, the Minister explained, would affect ancillary operations at collieries, but not coal production. As to the gas industry, the proposal for the financial year 1956–57 was £56,000,000, and the figure approved was £52,000,000, the reduction being likely to "bear primarily on distribution." For the electricity supply industry, the capital investment proposed for the financial year 1956–57 was £204 million, but the investment approved was £195 million. About this, the Minister said that since the proposed programme already represented a curtailment in distribution, the reduction would fall, for the most part, on generation.

Steel Developments

At the annual meeting of the British Iron and Steel Federation on March 20th, the president, Sir Ernest Lever, spoke about the long-term prospects for steel production. It was estimated, he said, that by 1958 this country's total steel output would be almost double the output at the end of the war. In the further expansion of output, Sir Ernest added, the steel industry would continue to make the most economical use of the available resources.

The steel industry's development programme continues. A few weeks ago, for example, the rebuilding was completed of the open-hearth plant at the Templeborough, Rotherham, works of the Steel, Peech and Tozer branch of the United Steel Companies, Ltd. The fourteen furnaces in the melting shop have been enlarged from 80 to 100 tons capacity, an operation which has been spread over the last three years, and, as a result, ingot production will be increased by 30 per cent.

Another development project which is beginning in Sheffield is that being undertaken at Tinsley Park by English Steel Corporation, Ltd. A geological survey of the area is in progress and site levelling is scheduled to begin towards the end of this year. The first stage will involve the levelling of a large part of the site and the erection thereon of open-hearth melting furnaces and heavy forging plant. Facilities will also be made available for the production of steel castings heavier than those now manufactured at the company's Grimesthorpe works. The cost of the scheme is estimated at £15,000,000, but expenditure in the next two years will not be great, as the specialised nature of the plant involves considerable design work and a long period of manufacture. An industrial development certificate has already been granted for the erection in one corner of the site of a new works to house part of the spring plant now at the Grimesthorpe works.

Technical Education

The publication of a White Paper, at the beginning of March, setting out the Government's plans for technical education, emphasised, once more, the importance of this subject. The White Paper has certainly stimulated public interest. Since its publication, there have been

announcements from various sources of schemes designed to encourage the education and training of engineers and scientists.

One announcement of special interest concerning technical education has come from the Imperial College of Science and Technology. The college is to introduce, next October, a new "preliminary science course." Its purpose is to help gifted young men and women who have concentrated mainly on arts subjects at school, but who decide at a late stage in their school career that they would like to study science or technology at the university. The new course will bridge the gap for them by providing a year's intensive study in mathematics, physics and chemistry; the successful student will then enter one of the college's normal three-year courses for the B.Sc. degree in science or engineering. The college hopes that among such young men and women there may be a potential source of the scientists and technologists urgently needed by the country at the present time, and that the new course may encourage them to turn to a career in science or engineering. It should be emphasised that the college expects that only a comparatively small fraction of its entry will come from this source and that the vast majority will still come from those who have specialised in science at school.

Road and Rail Schemes

During March, announcements were made about the start of work on two road schemes. The Ministry of Transport and Civil Aviation gave details of a new road bridge over the River Parrett at Bridgwater, Somerset, and of the second part of the Neath by-pass scheme. The scheme at Bridgwater includes a dual carriageway 530 yards long, to relieve congestion in the town centre, and a reinforced concrete bridge with three spans, totalling 160ft in length. The bridge has been designed by Messrs. Mouchel and Partners and the work will be carried out by Sir Lindsay Parkinson and Co., Ltd. The road works will be carried out by the Somerset County Council. The second stage of the Neath scheme will cost £394,000, it is estimated, and involves improvement of nearly 2 miles of roadway and bridges. The improved road will have a single 30ft carriageway, and the work is to be done to the designs of the Swansea borough engineer.

It was also announced by London Transport that work is to be resumed this spring on the prewar scheme to build a new station at Notting Hill Gate to replace the existing separate Central and Circle Line stations. The reconstruction is essential to the London County Council's scheme for widening the road at this point, where the present minimum width of 52ft is to be increased to 85ft between building lines. This work will be started by the London County Council as soon as completion of the new station makes it possible, in two or three years' time, it is stated. The estimated cost of the station works is £990,000.

A scheme for a railway between London Airport and Central London has also been under consideration, and a survey is to be undertaken, the British Transport Commission has stated. The scheme as at present envisaged would comprise a branch railway, probably from the neighbourhood of Whitton Junction, on the Waterloo–Richmond–Staines line, into the central terminal area of the airport. Various widenings and additional operating facilities are likely to be required between Whitton Junction and the London terminus, which is likely to be Victoria.

Land Drainage Machinery

During March, there were many interesting and informative papers presented to the institutions. One such paper is that entitled "The Development of Land Drainage Machinery and Equipment," which was read before the Institution of British Agricultural Engineers, on March 20th, by Mr. J. G. Bates, a Ministry of Agriculture plant engineer. Mr. Bates has directed attention to the big problem of carrying out annual maintenance work on upland hedgeside ditches.

The paper points out that there are approximately 186,000 miles of open ditch in England and Wales, of which roughly 13,000 miles are self-cleansing and require little or no attention, leaving 173,000 miles which require annual maintenance to prevent them from silting up. Up to date, 77,000 miles of the total have been improved with grant-aid, and of these, recent surveys have shown that about 40 per cent are being adequately maintained, 30 per cent partially maintained and 30 per cent not at all. Of the balance, i.e. approximately 96,000 miles, only about 2 per cent are being adequately maintained. Mr. Bates has estimated that if all the open ditches in the country were to be cleaned out annually, there would be sufficient work to occupy 700 machines working 1000 hours a year at approximately a quarter of a mile per hour! It is certainly a matter which deserves the study of engineers.

In this connection it is interesting to learn that the Royal Agricultural Society is organising a competition for farm ditch cleaning machinery. Medals will be awarded by the Society for mechanically operated appliances to be adjudged the most suitable for cleaning farm ditches with a top width of 4ft or less, and accessible from only one side. Entries will be required to be made by the autumn of this year and will then be inspected at work. Selected entrants will later be required to demonstrate their machines at a site chosen by the Society.

Institution of Civil Engineers

Brief reference is made here to some of the papers given at the Institution of Civil Engineers during February and March. A particularly interesting and varied group of papers was presented. Achievement in actual construction was described for such diverse jobs as a large harbour for oil tankers, and a scheme for water supply and distribution in a remote area of the Highlands. "The Design and Construction of Aden Oil Harbour," by J. E. G. Palmer and H. Scrutton (February 14th), contains a detailed account of the problems encountered in the design and construction of an oil harbour on a new site, with berths for four tankers. The berths were provided at three steel-piled jetties, and the work also included construction of a breakwater, 4126ft in length, of tipped rock,and 6,000,000 cubic yards of dredging, and reclamation. The principal factor influencing the design of the harbour was speed, both in design and construction. Detailed planning began on July 14, 1952; the harbour contract—a "target" contract—started on November 15, 1952, and the dredging contract a week later. The first tanker berthed on July 17, 1954, and the work was substantially completed by September 10th, after ninety-five weeks. The harbour was illustrated in the Colour Supplement of THE ENGINEER Centenary Number.

"The Caithness Regional Water Supply Scheme," by W. A. R. Baker, W. M. Jollans and J. N. Dale, offers a complete contrast in the technical problems involved. At Aden a vast scheme had to be built as rapidly as possible. The Caithness scheme is, by comparison, very small, but special administrative measures were necessary to control the rate of expenditure on the works, and to keep the whole scheme as economical as possible. The population of the county of Caithness, excluding the Burgh of Wick, is only about 15,500. Nevertheless, the unusual method of procurement and the efficient distribution of the water over considerable distances raised problems of no little engineering interest. The scheme consists of raising the top water level of Loch Calder to secure adequate storage, conveying water through pressure pipelines to a pumping station near Hoy, on the Thurso River, and there treating a small fraction of the water and pumping to supply. The bulk of the water is used for creating power to energise the pumps and for generating electricity for local needs in the station. From Hoy the water is pumped to two main reservoirs, whence it gravitates throughout the county in a reticulation of mains of various sizes. Surge pressures were a critical factor in the design of the Hoy pumping station; the governing of hydro-electric generators was considered to be the most dangerous cause of surge pressures and it was therefore decided to mount each pump on the same shaft as the turbine energising it, the usual electrical link being omitted.

Important developments in the design of structural steelwork were discussed at the meeting of the structural and building division held on February 28th. The theoretical background of the methods of design in the revised B.S. 153 was described, together with work involving full-scale tests of steel girders. The papers presented were: "The Basis for Design of Beams and Plate Girders in the Revised British Standard 153," by O. A. Kerensky, A. R. Flint and W. C. Brown, and "Experimental Verification of the Strengths of Plate Girders Designed in Accordance with the Revised British Standard 153: Tests on Full-Size and on Model Plate Girders," by E. Longbottom and J. Heyman. The authors of the first paper pointed out that they had reduced to a more usable form the complicated expressions derived from first principles for critical stresses in flanges and webs of single-web symmetrical and unsymmetrical girders; the design of girders with unequal flanges was made reasonably simple, with tables. It was considered that, when designers had become familiar and skilful with the proposed method, an overall economy of about 10 to 15 per cent in the weight of steel in plate girder and compound beam structures would be realised.

On the following Tuesday, March 6th, a discussion on "Toll Highways: Their Economics and Construction" took place. The three introductory papers were "Toll Roads," by H. D. Morgan; "Toll Bridges," by H. S. Smith and V. F. Bartlett, and "Turnpikes," by E. W. W. Richards. The idea behind these papers was to demonstrate the possibility of building some of the badly needed trunk road facilities in Great Britain—particularly long-span road bridges and tunnels—as financially self-liquidating projects. It was shown how a long-span highway bridge could be financed without resort to public funds, and would pay for itself in a number of years by the tolls charged. Reference was made to an impressive array of British projects for long-span bridges and tunnels, some of them designed in detail, but none of them included in present plans for actual construction.

Further evidence of the diversity of subjects within the Institution's purview is given by the subject matter of the three succeeding meetings held in March. On March 12th, the paper "Methods of Using Long-Term Storage in Reservoirs," by H. E. Hurst, was presented; on the 20th there was a symposium on general cargo handling, when the following papers were discussed:—"The Design of Ships from the Cargo-Handling Point of View," by J. A. H. Lees; "Civil Engineering Structures," by N. A. Matheson; "The Supply and Maintenance of Mechanical Equipment," by J. H. Shire, and "Handling of Port Traffic," by E. S. Tooth. And lastly, on March 27th, the history of a large-scale slip in a railway embankment, and subsequent remedial measures, were described in the paper "Earth Movement Affecting L.T.E. Railway in Deep Cutting East of Uxbridge," by J. D. Watson.

Technical Reports

Knife-Edge Bearings: No. 2 of a Bibliographical Survey of Instrument Parts. By P. J. Geary. Published by the British Scientific Instrument Research Association, Elmstead Woods, Chislehurst, Kent. Price 10s. 6d.—A technical introduction to this book deals with the different aspects of knife-edge bearings, and is mainly based on the information contained in the literature listed in the bibliography of some 160 references. The subjects considered include the use of knife-edge bearings in balances, weighing machines and strength-testing apparatus; for transmitting small movements in mechanical comparators and extensometers; as armature pivots in electromagnetic relays, and as pendulum suspensions; the loads knife-edge bearings can carry; the forms and included angles of knife edges and V grooves; materials used for knife-edge bearings; making, examining and mounting knife-edge bearing components; friction, wear and impact in knife-edge bearings; preventing corrosion in steel bearings, and varieties of bearing devised by inventors.

DOUBLE "V"-LINK BELTING.—A double "V"-link belting is now being made by H. Brammer and Co., Ltd., Hudson Road, Leeds, 9, for use where a driven shaft is required to run in opposite rotation to the driving shaft of an installation, such as in the case of crossed belt and multi-pulley drives. This belting is made in four sizes—$\frac{5}{16}$in, $\frac{3}{8}$in, $\frac{11}{16}$in and $\frac{3}{4}$in—for 40 deg. angle grooved pulleys, and three sizes—$\frac{1}{2}$in, $\frac{5}{8}$in and $\frac{3}{4}$in—for 28 deg. angle pulleys.

LITERATURE

Bearing Lubrication Analysis. By R. R. SLAYMAKER. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 40s.

WHILST many papers have appeared on the hydrodynamics of bearing lubrication since Reynolds' treatment of 1897, information is seldom presented in a form useful to the designer. In particular, research workers usually report the results of experimental or theoretical work in the form of non-dimensional parameters relating intensity of loading with speed and viscosity of lubricant. This is not very helpful to the designer because, until he has determined the dimensions of the bearing, he only knows the total load and not the load per unit area. Moreover, the viscosity of mineral oils varies considerably with the temperature so that an estimate of the operating temperature of the bearing becomes necessary before the value of the parameter may be computed.

To design a bearing, therefore, three things are required, an estimate of the friction torque and, therefore, the frictional heat generated, an estimate of the volume of lubricant passing which will carry away the heat and an estimate of the heat dissipated by conduction and radiation through and from the shaft and bearing housing. In modern high-speed bearings it is assumed that the majority of the heat will be carried away by the lubricant and the last factor is usually neglected. Even so, the position is still complicated by the fact that friction torque is a function of viscosity and the amount of oil passing is determined by the eccentricity which is in turn determined by the intensity of loading and the viscosity. The unwary designer may, therefore, find himself going round in circles if he attempts to design by a step by step process. Some generalised treatment leading to a heat balance is required.

In *Bearing Lubrication Analysis*, Professor Slaymaker uses the Sommerfeld-Harrison treatment for bearings of infinite width to illustrate how load-carrying capacity and friction are related to eccentricity and minimum film thickness. He then quotes Dennison's 1936 results for finite bearings, which are in the non-dimensional form previously referred to. He then shows how the flow rate of lubricant through a bearing fed from a central circumferential groove is determined by eccentricity and feed pressure. The viscosity of the lubricant will vary as it passes through the bearing and it is assumed for the purpose of calculation that the friction and load-carrying capacity are governed by the viscosity corresponding to the average bearing temperature. A graphical method is then used to estimate bearing temperature. Curves connecting viscosity and operating temperature with temperature rise divided by viscosity squared are constructed and the operating temperature and viscosity obtained from the point of intersection. This can be done for every set of bearing dimensions chosen. Clearance is regarded as a design variable and curves are given illustrating the effect of clearance, but a diametral clearance of 0·001in per inch diameter is recommended as being usually satisfactory.

A detailed case study of a ring oiled pedestal bearing supporting a flywheel shaft of a motor generator set is given. Proprietary ring oiled bearing pedestals were selected and, after an unsatisfactory test with a clearance ratio of 0·001 the bearing was modified by relieving the upper half and increasing clearance ratio to 0·0021, which avoided overheating. The minimum oil film thickness was then estimated from the equations but not measured. The example is an unfortunate one because two variables were changed simultaneously so that comparison with theory is not possible. Another case study is made of the main bearing of an internal combustion engine. The polar loading diagram for the bearing is given, but the surprising statement is made that, for design purposes, this can be replaced by a steady load equal to the average load but rotating at shaft speed. This may be a dangerous over-simplification and indeed we would consider it unwise to tackle such a design problem without considerably more basic information than is given in the book.

The book, which is based on a one-term graduate course in lubrication for students of machine design at Case Institute of Technology, attempts to compress the essential information for the machine designer into the compass of 104 pages. This has led to a very selective treatment. Thus, the theory of the fluid film is based on Sommerfeld and Harrison's papers of 1904 and 1920, respectively, and the design procedure recommended is based on Dennison's A.S.M.E. paper of 1936, no advantage being taken of the research which has been done since then on both sides of the Atlantic. No doubt, because unambiguous expressions exist for calculation of oil flow, the bearing having a continuous circumferential groove has been selected for the design examples. As is shown in Fig. 6, page 556, of our issue of April 22, 1955, this form of bearing is not particularly satisfactory and its use in British practice is fast disappearing. Whilst the mathematical development of the theory of a complete bearing is set out step by step, the most difficult feature, the integration of pressure round the bearing, is passed over with the remark " we shall find on integrating that..." In common with other American authors, the quantity $\eta N/p\,(r/c)^2$ is described as the Sommerfeld number. (η=viscosity, N=rotational speed, p=load per unit area, r=radius of shaft and c=radial clearance.) Sommerfeld actually wrote $U \propto P/\eta(c/r)^2$ where P=load per unit width and U=peripheral speed of journal. This inversion of a non-dimensional parameter may be permissible but, when the author describes $P/\eta N\,(c/r)^2$ as the " reciprocal of the Sommerfeld number," he is in danger of confusing the student.

The book is very well produced with diagrams and curves reproduced on a large scale. The student making his first acquaintance with the subject will find the principles of bearing operation and the problems to be solved in bearing design very clearly set out. As a manual for designers, however, the treatment is insufficient and the reader will only derive full benefit if, having mastered the principles, he consults more sophisticated works dealing with the design aspect.

Enthalpie-Entropie-Diagramme für Wasserdampf und Wasser. By L. S. DZUNG and W. ROHRBACH. Issued on behalf of A.G. Brown, Boveri and Cie., Baden, Switzerland. Berlin: Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price DM. 7·50.

THE present enthalpy and entropy diagram and tables for steam and water are the result of a research undertaken by Brown, Boveri and Cie., Baden, Switzerland, from 1951 to 1954. The units used are those of the MKSA-system (Giorgi-system), as recommended by the Fourth International Conference on Properties of Steam, held in Philadelphia in September, 1954. In this system, the fundamental units are the metre, the kilogramme, the second, and the ampere. It was adopted by Brown, Boveri for reasons of convenience in carrying out steam turbine calculations. The range covered is 0 deg. to 800 deg. Cent., and 500 bar for steam, and 600 bar for water. For present requirements this was felt to be sufficient. Not enough data were available to extend the tables further in a reliable fashion, and as the tables were urgently required no further scientific results could be awaited.

The advantage of the MKSA-system as compared with the technical system lies in not requiring the use of two inconvenient conversion factors, viz., the thermal equivalent and " g." Acceleration due to gravity only occurs in formulæ in which it enters as such. A further advantage lies in the clear distinction between mass, weight and force.

Numerical values in the superheat region are based on tables by Wukalowitch (Moscow, 1951), which, the authors state, were the only metric tables to cover temperatures up to 700 deg. Cent. Other data were obtained from Kennedy's measurements (U.S.A., 1950), while for the liquid region the values given by the same two authors were used.

Prestressed Concrete. Second impression. G. Y. GUYON. Contractors Record and Municipal Engineering, Lennox House, Norfolk Street, Strand, W.C.2. Price 70s.

THE English version of Monsieur Guyon's book has been revised in its second impression to include mention of some recent advances. Some new systems of prestressing are noted, and the chapter on fire resistance includes further test results and a section on the D.S.I.R.'s 1953 report on fire resistance. The new material also includes a note on the mechanics of the core anchorage, and on a theory of cracking. The original version of the book (in French) was reviewed in our issue of May 23, 1952.

A Pictorial History of Railways. London: Associated Newspapers, Ltd., Carmelite House, E.C.4. Price 2s.

THIS is a *Sunday Dispatch* publication designed to show in a pictorial form the development of rail travel in this country, and it includes an anthology of nineteenth century railway chronicles. The large number of illustrations of historical interest used in the publication have been reproduced from contemporary prints, etchings and engravings, a majority of which are in the collection at the Science Museum, South Kensington, and are well known to students of railway history. The publication concludes with illustrations and notes on modern designs of locomotives for various duties which have been built in this country for overseas.

Books Received

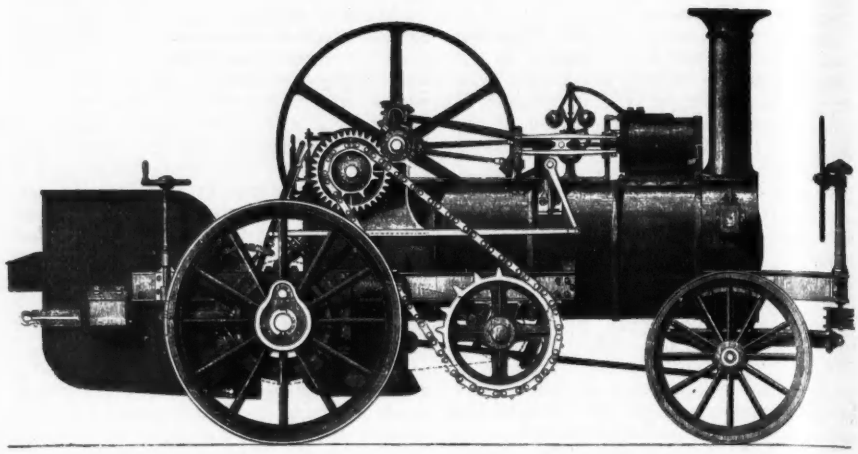
Machine Design. By Paul H. Black, McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 56s. 6d.

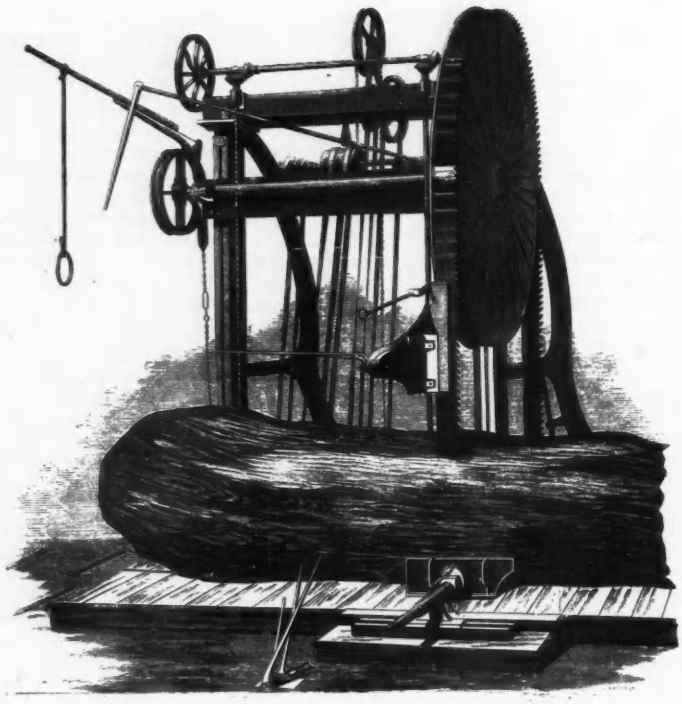
Die Design Handbook. Edited by Frank W. Wilson. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 109s.

Chemical Processing and Equipment. U.S. Atomic Energy Commission. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 45s.

Engravings of 1864

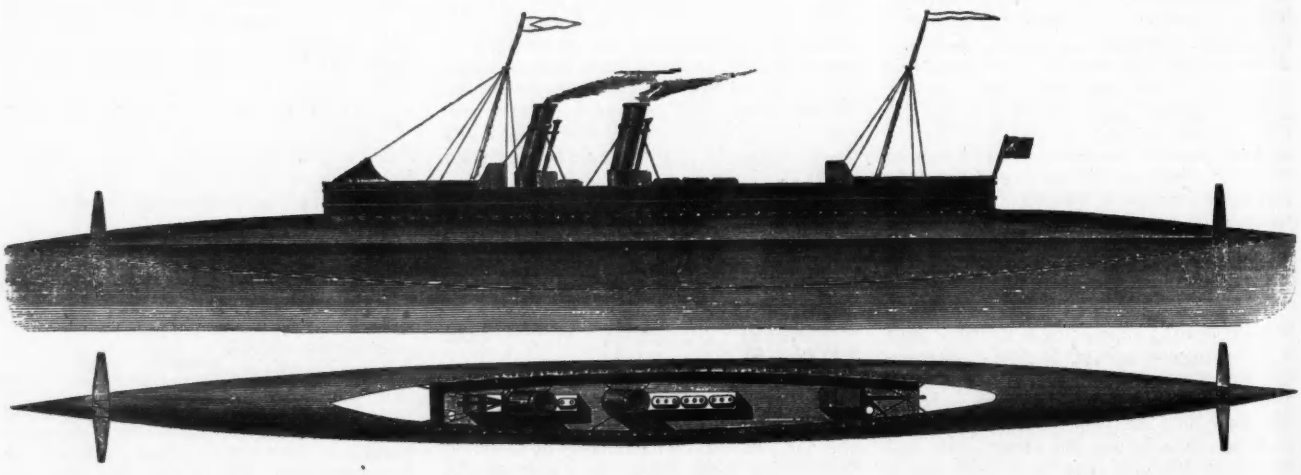
This engraving, reproduced from our issue of May 13, 1864, illustrates an 8 h.p. traction engine made by Brown and May, of Devizes. Our description of it reads :—"there is but a single cylinder, as it has been long known that the single crank is under perfect control, while for the weight and cost, far more work is done in one cylinder than in two, even of the same collective area. The gearing is unusually strong, one speed being brought down to nearly 22 to 1, while another for faster work is nearly 11 to 1. One of these engines with a 10in cylinder and 14in stroke, and weighing 11 tons 7 cwt has drawn upwards of 21 tons of additional load up a long incline of 1 in 16. The steam was ordinarily maintained at 80 lb, and the speed of the piston was 560ft per minute."





The engraving on the left shows an "endless band saw, 8in broad, and No. 15 gauge," which was constructed by Joseph Wilson, of Bradford, and described in our issue of February 5, 1864. This machine, it was stated, was capable of being worked by an engine of 7 h.p., and the saw "extended over two large pulleys or drums supported on massive iron standards, bolted to ashlar foundations." The travelling tables were 45ft long. The tables supporting the log were "arranged to carry the log past the saw to any extent, without stopping for readjustment, by which the necessity for transomes is avoided." They were capable of travelling at different speeds, in the same or opposite directions, and "of being set in motion (by levers shown in the illustration) reversed or stopped instantly." The description adds that "in order to facilitate the labourage the tables are placed level with the ground, thus conveniently arranged to receive the timber, which is at once adjusted."

The yacht illustrated below was built at Mr. John Hepworth's shipyard at Cubitt's Town, Isle of Dogs, by Messrs T. and L. Winans, the engines being constructed by Jackson and Watkins, Millwall. In a description, published on April 29, 1864, the length of the yacht is given as 256ft, the breadth being 16ft, and the depth 16ft, with a deep displacement of 500 tons. The description adds that "the engines will be high pressure surface condensing, and of greater power than usual for screw steamers of similar size." It says also that "the length of the hull, in proportion to its beam, is sixteen times, or about double the proportions in ordinary shipbuilding, but one fourth of its length at each end projects beyond the deck and bulwarks, having the length of the deck and bulwarks, but eight times greater than the beam of hull."



Electrical Engineers Exhibition

No. II—(*Concluded from page 280, March 30th*)

The fifth Electrical Engineers (A.S.E.E.) Exhibition—the largest electrical exhibition staged in this country—was opened at Earl's Court on March 20th by the President of the Board of Trade, Mr. Peter Thorneycroft, and ended on Saturday, March 24th. There were 310 exhibitors, that is, seventy more than last year. Among the 25,000 exhibits, ranging from micro-switches to electronic computers and large switchgear, more than 2500 new products were shown. A few of these new exhibits are briefly described in the following review of the exhibition.

Johnson and Phillips, Ltd.

A COMPLETE substation suitable for a medium-sized factory formed the basis of the exhibit shown by Johnson and Phillips, Ltd., Charlton, London, S.E.7.

The incoming supply to this substation was controlled by an 11kV ring-main unit comprising an "AG16" metal-clad vertical isolation oil circuit breaker with the "YP" oil switches recently introduced to comply with the new B.S. 2631/55. The transformer was a 750kVA unit using cold rolled steel to B.E.S.-T.1 (1954). The low-voltage board had an "L4" 1200A industrial oil circuit breaker on the incoming side and two "NL25" oil circuit breakers on the outgoing. Power factor improvement is effected by means of three 70kVAR capacitors fitted with contactor units.

The "NL25" equipment, illustrated in Fig. 5, was shown for the first time at this exhibition; it has been A.S.T.A. certified for 27·5MVA

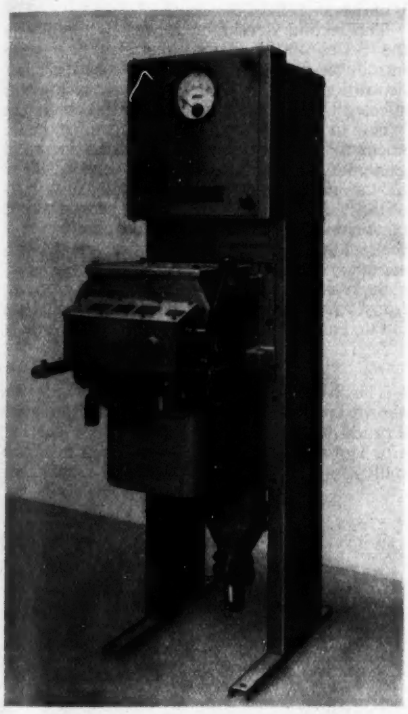


Fig. 5—Circuit breaker for 27·5MVA at 440V having an oil content of only 3½ gallons—Johnson and Phillips

at 440V, and is suitable for systems up to 660V and 600A. The unit is withdrawable and can be isolated without interrupting the supply to other units comprising the switchboard. The circuit breaker is of low oil content to provide additional safety. It is useful where ease of maintenance is of first importance and its construction and full complement of interlocks allow operation by unskilled personnel without risk. It is intended to meet the varying requirements of industrial substations and individual situations and is, therefore, designed to be extensible and easily rearranged. The circuit breaker is of the single-break design and the hinged pin of the moving contacts is maintained under positive pressure during opening or closing.

The contacts are of wedge and finger form, with backing springs to ensure high contact pressure, and have a high thermal capacity. The main current contacts are arranged so that contact pressure is increased under fault conditions. They have been developed to minimise the pinch effect associated with heavy fault currents and consist of two pairs of "S"-shaped contacts backed by a pair of conventional contacts. The contact closing follows a sequence in which the "S"-shaped contacts close first and are followed by the conventional contacts which are for current-carrying only.

The integral mechanism is of the free handle type, the position of the operating handle indicating whether the circuit breaker is open or closed. A reverse closing trip will automatically trip the circuit breaker at the slightest backward movement of the operating handle when closing.

The unit is fitted with isolating contacts which provide automatic isolation on both sides of the circuit breaker when it is withdrawn. These isolating contacts are located behind "Bakelite" sheets to shroud the live parts when the breaker is withdrawn; hinged covers are incorporated which can be located and padlocked over the ports of the contacts when the breaker is completely removed for maintenance. Interlocks prevent removal of the tank or main cover until isolation is complete. The circuit breaker cannot be plugged into service unless it is in the "off" position and the tank and top cover are in place. Up to four tripping devices can be fitted.

Overload calibrations range from normal rating up to three times normal rating, except where dashpot time lags are fitted, when the minimum and maximum settings are approximately 133 per cent and 200 per cent respectively of the trip coil (or current transformer) normal rating. Unauthorised interference with the setting is prevented by a protective cover shrouding the calibration tubes and dashpots. The busbars are of ample copper cross-section suitably supported to withstand the forces set up under short circuit conditions. The busbars are readily accessible when the sheet steel covers are removed.

Ferguson Pailin, Ltd.

Two interesting pieces of switchgear were among the exhibits shown by Ferguson Pailin, Ltd., Higher Openshaw, Manchester, 11: a 33kV, 1000MVA "VSLP9" indoor metal-clad switch unit and a single phase of a 275kV "OA300" outdoor air-blast circuit breaker. The "VSLP9" switch unit is a further development of the company's vertically isolated design. It is intended for use in power stations and primary substations at ratings up to 1000MVA and 1600A. The equipment provides for rapid fault clearance, integral earthing, positive and foolproof interlocking, together with visual indication of all operational positions, minimum space requirements and small oil volume. The unit is designed and tested to comply with the requirements of British Standard 116 (1952).

The 275kV air-blast circuit breaker consists of three single-phase units, each with twin air receivers interconnected by pressure equalising pipes. Each single-phase unit consists of two vertical porcelain support pillars, housing glazed porcelain inlet tubes which supply air to series-connected interrupter heads arranged in trefoil formation. A further porcelain support pillar, mounted at the centre of the air receivers, carries the rotating arm of the series isolator. Standardisation of interrupter heads and main insulator provides simple adaptability for other voltage ratings. Non-deteriorating porcelain insulation is used throughout the equipment. The circuit breaker is characterised by resistance-controlled voltage distribution, high speed of operation of the sequential isolator and fluid damping of the sequential isolator driving mechanism. The design allows for the addition of auto-reclosing operating mechanism.

Sunvic Controls, Ltd.

High-speed potentiometric recorders were shown by Sunvic Controls, Ltd., 10, Essex Street, Strand, London, W.C.2. These recorders are continuously self-balancing motor-driven instruments using electronic power amplification. They are designed for accurate measurement in laboratory or industrial conditions.

The operation of the recorder is based on a d.c. potentiometer, a fixed voltage being maintained across a slidewire by a dry cell and motor-driven rheostat. This voltage is verified automatically at intervals against a standard cell and is readjusted, if necessary, by the rheostat. The d.c. input signal to be measured is compared with voltage across the slidewire, and the difference voltage is amplified and used to drive the potentiometer to balance, and at the same time to move the indicating pointer and the recording pen or multi-point printing mechanism. To obtain the necessary stability an a.c. amplifier is used, the d.c. difference signal being converted to a mains frequency alternating voltage by a vibrator. The speed of the recorder is such

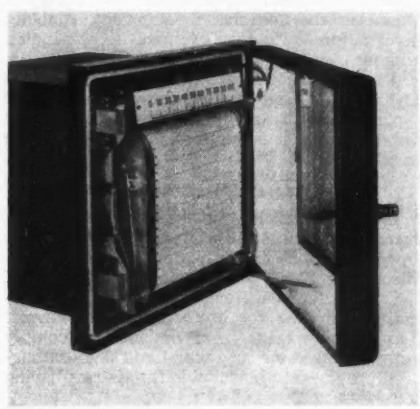


Fig. 6—Continuously self balancing potentiometric recorder designed for laboratory or industrial use—Sunvic

that the whole width of the chart (10in) can be traversed in one or two seconds. For out-of-balance signals greater than about 5 per cent of full scale the amplifier becomes saturated, and the motor runs at its maximum speed. To prevent overshoot an a.c. tachometer generator is built into the balancing motor which gives an output proportional to speed, and a corresponding signal fed into the amplifier retards the motor as the balance point is approached. The roll charts are 120ft long and the drive is by means of a six-speed gearbox. Speed selection is by two levers and no changing of gear wheels is necessary. Two forms of recorder are available: single-point recorders (RSP2), fitted with a siphon pen, drawing a continuous trace; and multi-point recorders (RSPM2), two, four, eight or sixteen point, with dot and numeral single colour print wheels, the interval between successive printings being adjustable by sliding gears to either five or fifteen seconds.

The sensitivity of the recorder enables it to respond to input signals of less than 1 microvolt, the full-scale range being 500 microvolts in the single-point recorders and 1 millivolt in the multi-point recorders. Range changing is done by removing a plug-in range bobbin and inserting the appropriate unit for the required range. The overall accuracy is given as ±0·5 per cent of scale span for spans not less than 1mV, and ±4 microvolts for the 0·5mV range. The sensitivity is limited by the slidewire steps to 0·2 per cent of the scale span.

The recorder is in a sheet metal semi-flush-fitting case (fig. 6) having a hinged door with

rubber gaskets and handle locks. Internal chart illumination is provided.

Lancashire Dynamo Group

A new range of simple adjustable speed drives from ¼ to 1 h.p. was shown by Lancashire Dynamo Electronic Products, Ltd., St. Stephen's House, Victoria Embankment, London, S.W.1.

These drives are simpler than the electronic motor control equipments, but have the same properties : armature *IR* drop compensation providing a flat load-speed characteristic ; current limit to provide fast constant-current acceleration and to prevent motor overload and damage to the driven machine on stalling. Provision is also made for reversing, dynamic braking for rapid stopping and " finger-tip " control of speed over a 10 : 1 range. The speed control drives are available as standard with either mercury-vapour or inert-gas thyratrons, the latter being used where extreme ambient temperature conditions prevail and where a short thyratron heating time is required. In each equipment the control unit is easily detachable for servicing.

Another new exhibit on the same stand was a " packaged " form of Ward-Leonard drive with magnetic-amplifier control as an alternative to the company's electronic control system. The equipment shown was of 2·5 h.p. rating. It provides a 15 : 1 speed range against constant torque and has compensation for armature *IR* drop to give a flatter load-speed characteristic. It has the inherent properties of the Ward-Leonard system : on deceleration regenerative energy is stored in the conversion equipment, enabling acceleration and sudden overloads to be handled without overloading the supply.

Another member of the group, Lancashire Dynamo and Crypto, Ltd., showed, for the first time, a 10kW flameproof alternator, certified for Group II gases, as supplied for emergency use in oil refineries.

Micanite and Insulators, Ltd.

Electrical insulation, in the form of insulating materials as well as finished insulators, was shown by The Micanite and Insulators Company, Ltd., Blackhorse Lane, Walthamstow, London, E.17.

One of the main exhibits was a 275kV re-entrant bushing for an outdoor transformer. This bushing (Fig. 7) is designed to comply with specification of the Central Electricity Authority and to be suitable for systems having an impulse withstand level of 1050kV. The main insulation is provided by an interior condenser bushing of paper, impregnated with oil, which is hermetically sealed within the enclosing porcelain and metal components. A " Paxolin " synthetic-resin-bonded paper laminated cylinder with a diameter of 67in was also on show.

Among the interesting new insulating materials exhibited was an improved copper-clad laminate which is under development. Other new materials were : polyurethane-coated " Terylene " fabrics, Ethenoid coated cotton fabrics, pre-impregnated polyester glass fabrics, polyester-bonded flameproof glass laminate, ethoxyline-bonded glass fabric laminate, and ethoxyline-coated " Terylene " fabrics.

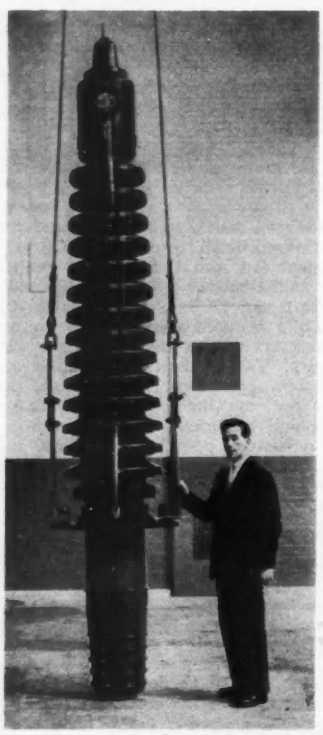


Fig. 7—275kV re-entrant condenser bushing for outdoor transformer—Micanite and Insulators

Hedin, Ltd.

A vertical loading furnace with a self-contained steam-atmosphere container was shown by Hedin, Ltd., Commerce Estate, South Woodford, London, E.18.

The equipment (Fig. 8) consists of a vertical furnace with gantry and hoist, a control unit, a quench tank and a heat resisting container fitted with an automatic ball valve for filling and emptying and retaining sufficient water for steam generation. This container is equipped with a safety valve and thermocouple.

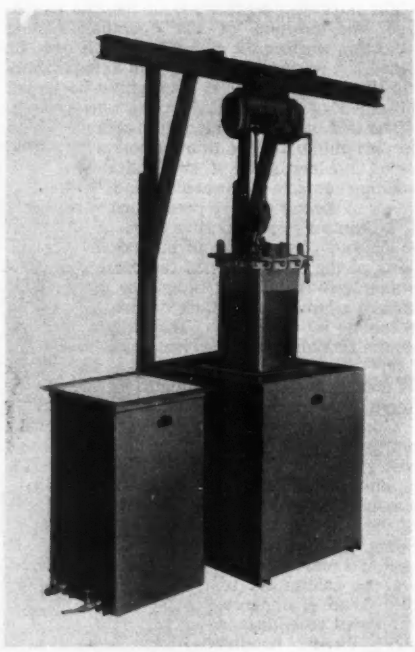


Fig. 8—Vertical-loading furnace with self regenerative steam atmosphere container, arranged for automatic quenching—Hedin

In operation, the empty container is dipped in the water tank and the action of the ball valve allows a certain amount of water to be retained when the container is removed. The container is then loaded and lowered into the furnace, whereupon steam is generated, thus providing a protective atmosphere before the charge has reached an oxidising temperature. After the necessary period of soak, the container, still under atmosphere conditions, is transferred back to the water tank.

The ball valve allows water to enter, quenching takes place, and the steam so generated escapes through the safety valve. When the container is raised from the tank, sufficient water is automatically retained to generate steam for the next charge. Unloading can take place immediately.

Steam generated in the container provides a cheap protective atmosphere for the heat-treatment of non-ferrous metals, particularly for beryllium copper and the solution treatment of aluminium.

It is stated that one unskilled operator can manage three or four of these equipments, the only operation required being that of loading and unloading and operating the hoist.

Brook Motors, Ltd.

A fractional horsepower motor, the " Merlin," designed to suit washing machines and other domestic appliances, was shown by Brook Motors, Ltd., Huddersfield. In incorporates many of the characteristics of the company's " Gryphon " motor, but its overall length is less to enable it to be fitted into a washing machine cavity. The stator is a single steel shell with cast iron or pressure-die-cast aluminium end shields, and detachable pressed-steel feet fixed by four bolts. Fan blades are incorporated in the end rings of the cast aluminium rotor which is dynamically balanced. White metal sleeve bearings with oil-impregnated felt-packed cavity provide lubrication for the shaft and allow the motor to be run with the shaft extension up, down or horizontal. The motor is a split-phase machine with a starting winding controlled by an internal centrifugal switch, giving a starting torque of 175 per cent full load and a starting current of six times full load. For washing machine duty the overall dimensions are : length 9·906in ; height 6·687in ; centre height 3·5in ; shaft 0·5in dia. with flat.

Standard Telephones and Cables, Ltd.

Two new developments in rectifiers were shown by Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2. The first is an example of the newest semi-conductor conversion equipments now being developed by the company. It consists of an oil-immersed silicon-rectifier transformer unit rated at 400V, 15A. The overall electrical efficiency of this kind of rectifier exceeds 95 per cent. Compared with a selenium transformer-rectifier of the same rating, the new equipment is only one-tenth of the weight.

The second development was exemplified in the Series 400 industrial rectifiers now being introduced into the " Sentercel " range. Selenium deposition on the plates of these rectifiers is effected by a vacuum evaporation process which is new to this country. During manufacture the selenium compounds are vapourised in special vacuum ovens and are caused to " condense " on to the rectifier plates. Important advantages of this technique are the greatly improved control of selenium deposition and better elimination of the last traces of contaminants, leading to corresponding increases in rectifier efficiency.

A typical medium-power selenium rectifier-transformer unit in the display is air cooled and is rated at 250V, 1000A for continuous working.

Westool, Ltd.

The coil winder illustrated in Fig. 9 was shown for the first time at this exhibition and is a product of Westool, Ltd., St. Helens, Auckland, Co. Durham. The main characteristics of this multi-coil winding machine is its ability to accom-

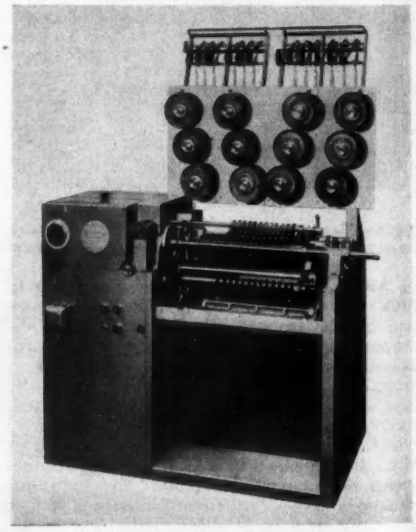


Fig. 9—Coil winding machine carrying twelve 6in diameter reels with winding range of 20 to 46 s.w.g.—Westool

modate twelve reels, each of 6in diameter, with a winding range of 20 to 46 s.w.g.

The machine has a traverse from $\frac{1}{16}$ to 6in, with a maximum effective winding length of 18½in. The maximum coil diameter is 4½in and the minimum ⅜in. When changing from one gauge wire to another, the operator or setter can see the required setting from a small dial. The coil winder is driven by a 1·25 b.h.p., a.c. motor with electric clutch control ensuring smooth acceleration in speed from 0 to 2500 r.p.m. It is equipped with a pre-setting electric revolution counter with a Warner electric brake on a mandrel headstock to ensure accurate control and prevent over-running. Starting is by means of an "inching" pedal after which push-button control becomes effective and the machine runs automatically. An automatic cut out operates in the event of wire breakages.

Allen West and Co., Ltd.

A recently developed control centre for crane operation, in which the master controllers for all motions are grouped in relation to an adjustable seat for the driver, was shown by Allen West and Co., Ltd., Brighton, Sussex. One form of equipment has master controllers for three motions, two of which are coupled to one control lever by a universal mechanism. An alternative design has cam-operated drum controllers. Rapid changing of the contact system can be effected by withdrawing two screws, without disturbing any terminal connections. The cams are of single-start design, machine cut from laminated resin sheet and they engage with steel rollers. The copper contacts are silver-faced. Universal coupling to a single lever can be arranged for related motions such as cross traverse and long travel. The controllers are driven by concentric shafts and the two motions can be operated independently or simultaneously.

Westinghouse Brake and Signal Company, Ltd.

Three new battery chargers were shown by the Westinghouse Brake and Signal Company, Ltd., 82, York Way, King's Cross, London, N.1. One of them was a sequence battery charger, designed to charge two or more batteries in succession, the change-over from one battery to the next and the final shut-down being completely automatic. It is designed to be capable of recharging, from normal discharged con-

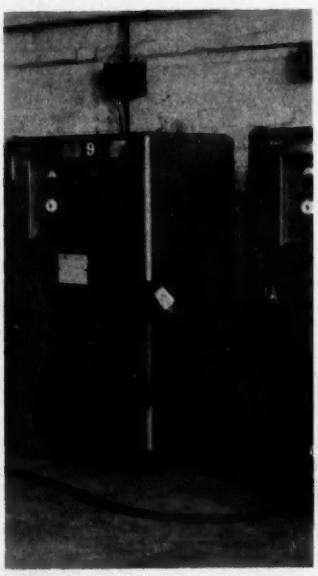


Fig. 10—Sequence battery charger for charging two or more batteries in succession, with automatic changeover and final shut down—Westinghouse

dition, up to three lead-acid batteries or four alkaline batteries in twenty-four hours, and is therefore well suited for charging battery-electric vehicles operating two or three eight-hour shifts and using two or three batteries. Part of a typical installation of sequence battery chargers at the Cannings Marsh Tobacco Bonds, Ltd., Bristol, is shown in Fig. 10.

Another new battery charger was that built for British Railways for recharging diesel locomotive batteries. It is designed for recharging two capacities of lead-acid or alkaline batteries, the appropriate circuit being brought into operation by a selector switch. The third battery charger was a shockproof "tropicalised" unit designed for vehicle mounting and developed for the Ministry of Supply.

Electrical Remote Control Company, Ltd.

An electronic timer, primarily intended for control of large spot welding guns as used in the mass manufacture of motor-car bodies, was shown by Electrical Remote Control Company, Ltd., South Road, Templefields, Harlow New Town, Essex. The timer controls four operations: first, squeeze, during which an air valve solenoid is energised and the air valve pushes forward welding electrode to the sheet steel; secondly, weld, when the timer energises coil of the welding contactor switching on the welding current; thirdly, forge, when the welding contactor is de-energised and the weld cools off; finally, the off period. The weld period can be adjusted between 2 and 100 cycles, the remaining sequences can be adjusted between 5–100 cycles. The timer has also a switch for continuous welding and single cycle operation.

Woods of Colchester, Ltd.

An improved design of draughtproof "Xpelair" ventilators was shown by Woods of Colchester, Ltd. In place of the conventional circular outlet baffles the restyled "Xpelair" has an outlet grille which is much more compact and less conspicuous. Another change is that the usual circular shape has been changed to a "square with curved sides." A new model with a 6in diameter fan has been introduced, making a range of three sizes, the others having fans of 7½in and 9½in, as previously. In cream plastic, the new small size is suitable for domestic kitchens. The two larger models are now produced in black plastic. All three sizes incorporate the "Xpelair" built-in iris shutter. Linked with an integral fan switch and operated by two nylon cords, the shutter is opened and closed as the fan is switched on and off.

Elliott Brothers (London), Ltd.

Among the new products shown by Elliott Brothers (London), Ltd., Century Works, Lewisham, London, S.E.13, was the Bristol's hermetically sealed "synchroverter" switch. It is a polarised single-pole, double-throw, non-resonant chopper which provides break-before-make action in synchronism with the current wave of the driving force. At frequencies from 0 to 1800 c/s it connects low-power d.c. signals into alternating voltages which can be amplified and applied to electronic, electrical and servo systems. It can also be used as a precision synchronous rectifier.

Another exhibit, the Elliott hermetically sealed, moving-coil relay, is constructed on a standard valve base which can be plugged into a valve holder in exactly the same way as a valve. With inputs of under 10 microwatts this relay can be used to break powers of 2W and finds wide application in electrical control circuits wherever reliable operation and compact design are necessary.

A recent development which was shown was the mercury arc loss tester. It consists of a precision suspended dynamometer wattmeter, auxiliary unit and precision d.c. ammeter for measuring arc loss in mercury arc rectifiers by the method developed by Dr. Lamm, of A.S.E.A., since standardised by the Swedish Standards Association, and adopted in draft recommendation by the Internal Electrotechnical Commission.

Evershed and Vignoles, Ltd.

Two new "Megger" instruments will be exhibited by Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, London, W.4. One, the mains-operated Series 1 "Megger" insulation tester, has been developed for three-voltage operation with testing pressures of 100V, 250V and 500V (selected by switch) and a range extending up to 10,000 megohms. The other, an addition to the range of Series 2 instruments, is the three-voltage, hand-driven "Megger" insulation tester. This instrument has testing pressures of 250V, 500V and 1000V and measures up to 200 megohms. Another innovation shown at the exhibition is the replacement of aluminium by steel for the casing of the "Megger" Series 2 intrinsically safe insulation and continuity tester. Steel is now being employed to conform with a National Coal Board directive dealing with the possibility that aluminium may be unsuitable for use at the coal face.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GUIDE TO TERMS USED IN A.C. POWER SYSTEM STUDIES

No. 2658 : 1956. Price 6s.—Power system engineers and designers of electrical generating machinery have in the past been hindered by the lack of uniformity of the terms, and their meanings, used in their work. The problem has extended to the teaching profession and to writers of technical papers. This guide was prepared by the Electrical Research Association and remedies the situation by defining the terms in most common use. Since the publication is intended as a guide rather than merely as a glossary, the definitions and explanations have been made more detailed and descriptive than is usual in a British Standard glossary. The contents cover the following: load response terms, stability terms, synchronous machines, symmetrical components, governor characteristics, transformers, lines and cables.

Letter symbols for many quantities appear in the text and are collected for reference after the list of contents. Publications of the American Standards Association, the American Institution of Electrical Engineers, and the International Electrotechnical Commission have been consulted during the preparation of this guide. It is intended that the Guide be reviewed after a year. A revised edition will then be issued, including any changes found desirable.

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

Nos. 1470–77 : 1955. These are revised editions of standards first issued between 1948 and 1951, and deal with various wrought forms as follows:—No. 1470, sheet and strip, price 7s. 6d.; No. 1471, drawn tube, price 6s.; No. 1472, forgings and forging stock, price 6s.; No. 1473, rivet, bolt and screw stock for forging, price 6s.; No. 1474, extruded round tube and hollow sections, price 6s.; No. 1475, wire, price 6s.; No. 1476, bars, rods and sections, price 6s.; No. 1477, plate, price 6s.

Particular attention is drawn to the fact that the requirements for wire, previously covered by No. 1474 and No. 1475, have been incorporated in one standard, No. 1475. This latter therefore applies to wire for welding as well as for general purposes. It does not apply to wire for electrical purposes, requirements for which are specified in No. 2627. The number 1474 has been allocated to a new standard for extruded round tube and hollow sections, and No. 1471 now refers only to drawn tube. No. 1472 has been extended to include separate sections for forgings and forging stock, and for stock for forging; and No. 1473 now includes separate sections for stock for small rivets and for stock for small bolts and screws.

The system of nomenclature adopted throughout all standards in the earlier series has been retained, but the modifications outlined above have necessitated the introduction of two new prefix symbols, "V" for extruded round tube and hollow sections and "B" for bolt and screw stock. The prefix symbol "W" is not now used, as the symbol "G" is applied to all materials in No. 1475.

Three new materials have been introduced in the series, namely, super-purity aluminium designated 1, and two aluminium-magnesium-silicon type alloys designated H20 and H30, which have been included immediately following H10 because of their similarity to that material. Alloy H20 contains an addition of copper, and also manganese and/or chromium, while H30 is a copper-free alloy with an obligatory manganese content.

Some amendment has also been made to the composition limits of the other alloys in the series, and in certain cases composition limits and mechanical properties have been rounded in accordance with No. 1957, "Presentation of Numerical Values (Fineness of Expression; Rounding of Numbers)." Other modifications are the introduction of two new conditions, one applying to rivet, bolt and screw stock, the second to wire, and the extension to wrought materials of a condition previously applicable only to castings, and changes in the particular alloys and conditions specified for each wrought form. The tolerance tables in several of the series have been extended, and minor amendments made to the values specified.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. I

THE annual general meeting of the Institution of Naval Architects opened on the morning of Tuesday, March 20th, in the Weir Lecture Hall at 10, Upper Belgrave Street, London, S.W.1, and was preceded by the presentation of a Presidential Badge. This had been made to the design of Mr. L. C. Evetts, M.A., of Durham University, on behalf of Vickers Armstrongs, Ltd., and the presentation was made by Mr. E. L. Champness, M.B.E. The annual report, read by the secretary, recorded that Mr. L. Woollard, M.A., and Sir James McNeill, K.C.V.O., C.B.E., F.R.S., had been elected honorary vice-presidents. A further note showed that the membership roll totalled 3866, an increase of 138 during the year.

The first award of the William Froude Gold Medal was made to Professor Sir Thomas Havelock, M.A., D.Sc., F.R.S., and premiums were presented to Dr. W. Muckle, M.Sc., Ph.D., for his paper "The Influence of Proportions on the Behaviour of Partial Superstructures Constructed of Aluminium Alloy," and to Professor G. Aertssen, for his paper "Sea Trials on a 9000-Ton Deadweight Motor Cargo Liner." Mr. W. J. Holt received the Samuel Baxter Prize for his paper "Recent Developments in Naval Life-Saving Equipment," and Mr. J. E. Church was the recipient of the Watts Prize for his paper "Crew Accommodation for Improved Type of Dry Cargo Vessel." Duke of Northumberland prizes were awarded to Mr. J. G. Bell, of the Royal Technical College, Glasgow; Mr. R. C. Caws and Mr. M. J. Rushton, of Southampton Technical College. Awards of National Certificates in Naval Architecture at Ordinary level numbered 136, being ten more than in 1954, while the total of certificates at higher level, at seventy, represented a considerable improvement on the twenty-nine of the previous year. Mr. M. H. Corbin received the first prize of the City and Guilds of London Institute and Mr. J. Grinstead the second prize.

The report announced that Sir V. G. Shepheard, K.C.B., and Mr. J. M. Murray, M.B.E., D.Sc., had been nominated to represent the Institution on a Nuclear Energy Marine Propulsion Panel, and included brief summaries of the research work forming the programmes of the Ship Division of the National Physical Laboratory, the British Shipbuilding Research Association, Pametrada, and the British Welding Research Association. Particulars of the scholarship awards made in 1955 were given and also of the scholarships offered for competition in 1956.

Presidential Address

The following is an abstract of the presidential address given by Viscount Runciman after the adoption of the report.

Among the activities of the past year the must unusual was the autumn meeting held in Yugoslavia, which at least contributed something towards the friendship of the two countries concerned. A matter which I think we are unlikely to lose sight of is nuclear energy, and we are well represented on the panel which has been set up by the Institute of Marine Engineers in conjunction with our own Institution and other suitable bodies. I understand the Admiralty takes the view that it is only a question of time before nuclear energy is the main source of power, not only for warships, but for merchant vessels as well.

While it has been comparatively easy during the year for the shipowner to place an order, it has been extraordinarily difficult to get the results. However, we know what a shortage there is of skilled shipyard labour and of design and drawing staffs, and that there are a great many people besides shipbuilders who want steel plates. There are also a large number of people who want ships, so that it is not surprising that order books should be full and that the cost of ships should show no immediate sign of a substantial drop. This is satisfactory because there is at least no visible over-production of ships in the world, and I suppose it does not matter if everybody else's costs are as high. However, one is troubled by the suggestion that there are other countries capable of producing quite good ships at prices and in times which the shipowner, a competitor in the international market, may be tempted to accept. We are largely an international body, and our purpose is to see that the design of ships is improved, and in times like these it is more than ever important that designs should be good and that they should be economical, both in the use of materials and in running costs.

In a world of shortage of materials and of people who make use of them our best chances of getting somewhere must lie in so arranging the use of our materials and the employment of our labour that we get the best out of both. That is difficult to-day and involves a great deal more than drawing lines on paper, but unless we do so we shall fail to gain those advantages to which our skill and industry entitle us. I am interested to see that the Admiralty is continuing its researches into new materials. The use of plastics is being ever more seriously considered, particularly for boat building, and I hope that when such development includes ships' lifeboats we shall not find, as in the past, that the conservatism of the Ministry of Transport is greater than the desire to see the application of modern developments.

There is also the problem of the simplification of upkeep and maintenance. I have said before that I cannot understand why nobody has invented something which is distasteful to barnacles, and why we have to put ships into large holes, expensively excavated, to apply to their bottoms substances which do not stay there long enough. I think there is much room for research on the protection of the underwater parts of ships as much from the organic creatures as from corrosion from other sources. We know about the progress of anodic protection, and I gather that, particularly in Her Majesty's ships, developments are contemplated and work is being done which I hope will eventually be made available to the rest of us.

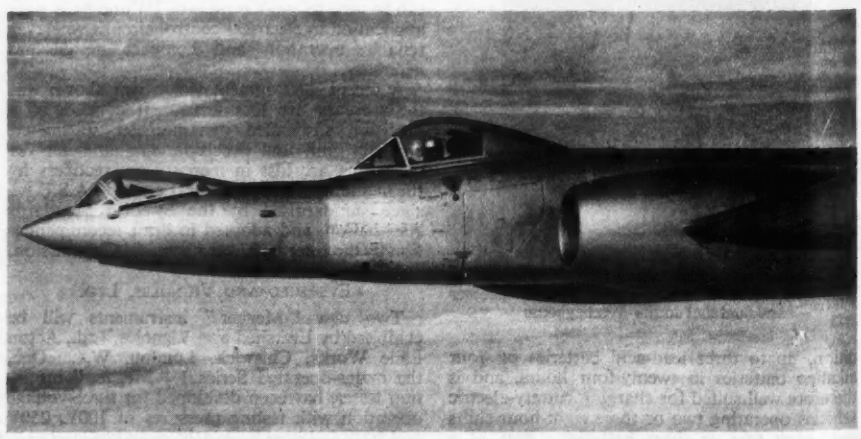
It seems certain that throughout the world labour will be in fairly short supply for some time to come; that being so, it is not only commercial common sense, but a major public duty, to ensure that labour is not wasted in doing things which can be done in other ways.

The design of ships is a slow and laborious process and no ship ever will be perfect. It is really a matter of being quite sure that you have the best ship for the job to be done. One of the facile assumptions of non-technical people is that a ship is like a motor-car, that it can be produced in series and that one will work as well as the one before. But those who try to run ships under conditions of international trade in times of peace know that the only way of fulfilling at a reasonable cost the requirements of the world for sea carriage is to be quite sure that in any particular trade you have ships most suited for that trade. It is in that long process of the evolution of individual designs for individual purposes that I think this Institution will continue to play a valuable part.

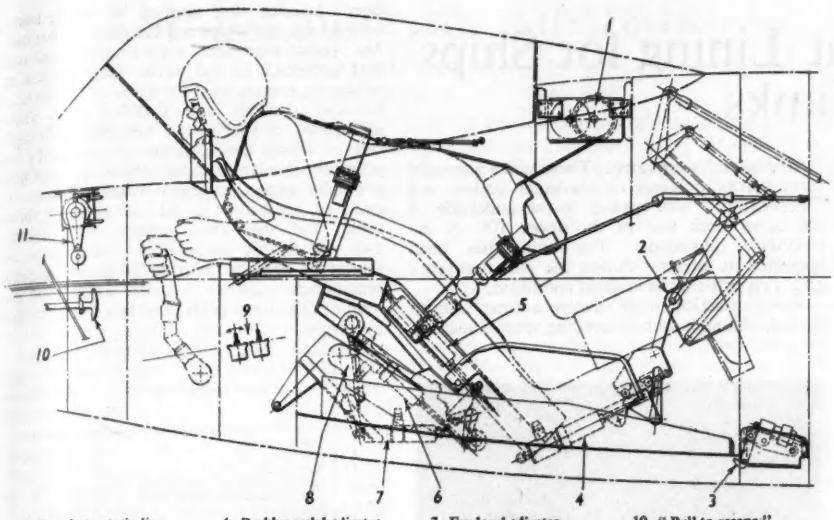
(*To be continued*)

Prone Pilot "Meteor"

LOSS of consciousness in a manœuvring aircraft is attributed to acceleration along the path of blood from heart to head, and is therefore unlikely to occur when acceleration is in the direction from front to back of the airman. To take advantage of this it has been proposed that pilots should fly in a recumbent attitude, and that this might also allow the aircraft to be made smaller. The true prone position, lying on a flat bed tilted slightly upwards at the front, was found to become uncomfortable after a short time, but a semi-prone position,



The modified "Meteor" in flight. The downward vision window can be discerned



1. Parachute static line.
2. Rudder pedals.
3. Escape door catches.
4. Rudder pedal adjuster.
5. Thigh length adjuster.
6. Thigh angle adjuster.
7. Eye level adjuster.
8. Escape door jack.
9. Bed adjustment switches.
10. " Pull to escape."
11. " Prepare to escape."

Arrangement of prone pilot's cockpit

with the body bent at the hips, was not so limited. To test these conclusions a Reid and Sigrist training aircraft was fitted by the Royal Aircraft Establishment with provision for a prone pilot in front of the normal cockpit, and a considerable amount of test flying carried out. This led to the decision to test the system in a high-performance aircraft, and a Gloster " Meteor 8 " was modified for the purpose by Sir W. G. Armstrong Whitworth Aircraft, Ltd.

The bed is in three parts, the main couch supporting the body of the pilot and ending at the front in two shoulder " hooks," to which the harness is led, with a soft rubber chin rest between them. To this is pivoted the thigh chassis, an electric actuator being provided to change the angle between these two parts. At the end of the thigh chassis is the knee chassis, and another electric actuator moves it to and fro to suit varying lengths of thigh. The bed is padded with foam rubber covered in leather, and the harness straps the pilot down on to it, being secured by an assistant. A third actuator is provided to rock the bed about an axis in front of the pilot's knees in order to adjust his eye level. Before the seat was installed, the pilots tried it in attitudes ranging from 10 deg. nose up to 80 deg. nose down ; the latter position, of course, could not be endured for long.

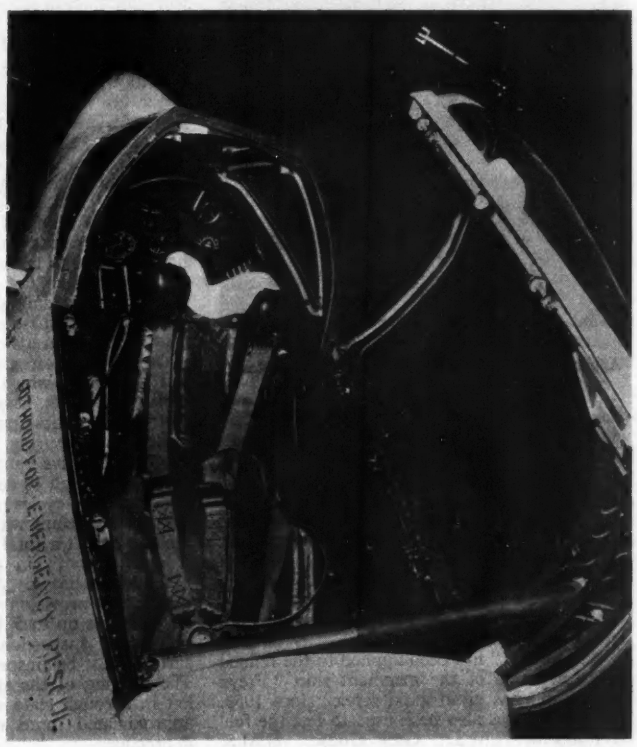
Since the pilot's lower legs rest on the knee chassis, ankle movement only is applied to the rudder pedals ; to suit the natural movements of the feet, they are arranged so that the pedal, or rather bucket, moving away turns further than the one approaching. A link connects the rudder pedal mechanism to a trolley running along the centre of the knee chassis, and the position of this trolley is regulated by a fourth electric actuator to bring the buckets comfortably to the pilot's feet. Escape from the aircraft is made downwards, and when the " prepare to escape " lever is moved, the link to the rudder controls opens and allows the buckets to be pulled away aft by rubber cords in tension. The link itself, which is between the legs of the pilot, folds away forward so as not to injure him as he slides out. At the same time, the knee chassis falls down to lie in line with the rest of the bed, its side plates serving to guide the pilot through the hatch in the underside of the aircraft.

The bed was installed in a new nose section provided with controls and instruments enabling the prone pilot to taxi, take-off, fly and land the aircraft. The engine starting and fuel system controls were left solely to the pilot in the normal cockpit. The nose position had a normal windscreen and hood, and also a window in the floor of the aircraft. Gyroscope instruments were mounted on a vertical panel between two sloping panels carrying the remaining dials. Below and in front of the bed were the trimming controls, undercarriage and flap selectors, and the switches for the bed actuators. On the underside of the bed, just below the chin rest, was a " harness slack " control, and further down the release for harness and oxygen connection. On the right of the bed was placed a rest for the forearm, and in front of it a short control column with normal movements. The entire bed was mounted upon a door in the underside of the fuselage, which is pivoted at its front end to open outwards and allow the pilot to escape ; when a handle is pulled, hydraulically operated catches at the rear of the door are released and a ram forces the door outward. Release of the harness then allows the pilot to fall clear, and a static line actuates the parachute release when he is away ; a barometric pressure release prevents the parachute opening above 10,000ft. Since the safety pilot cannot see the prone pilot, there were fitted not only a normal and emergency intercommunication system, but also signal lights controlled by the pilot in the other cockpit and a " prone pilot away " signal worked by the static line.

Because of the great reduction in stick forces available, all control circuits were converted to optional power assistance with Fairey "Hydro booster " units, control reverting to manual in case of any failure. A doll's-eye indicator showed that a piston-rod pawl had engaged on each system. Since the nose cockpit was immediately in front of the nose wheel, an additional emergency retraction actuator was provided for it. Other modifications were an increase in the tail fin area, restriction of the rudder travel, and the provision of a spin recovery parachute in the extremity of the fuselage. Pressurisation was discarded.

Test flying by the Institute of Aviation Medicine has shown that the unusual attitude does not prejudice the pilot's control of the aircraft. The prone position, when flying in calm conditions, was found to be more comfortable and allow the pilot to relax almost completely. But, obviously, the field of vision is very restricted—hence the need for a safety pilot—and the shallowness of this field rendered difficult manœuvres in the pitching planes, such as loops. It also hindered contact navigation, since if a landmark was not seen before it was reached, finding it was difficult, the downward vision window being too small to serve this purpose. Maps and any other objects required in flight had to be left on the cockpit floor, since the overall pockets could not be reached, while to fold a map was an enterprise. The disadvantages of the bed became obtrusive when flying through turbulence ; however tightly strapped in, the pilot's chest had to deflect under the impulse of the bump, so that he was partly winded. More noticeable were the limitations of the chin rest, which was used to support the front of the chin, and hammered the pilot intolerably in bumpy conditions. It was predicted that loads of 8*g* to 9*g* would break the pilot's jaw-bone, and to overcome this limitation a special flying helmet is proposed. The chin rest apart, the expected *g* tolerance was realised ; it proved impossible to black out the pilot within the airframe limitation of 7*g*. (The seated pilot used a pressure suit.)

The conclusions drawn from the building and flying of this project were that about 5in might be saved on the height of the cockpit enclosure, and that piloting in the semi-prone position was feasible, with a possible need for aids to vision such as periscopes.



The bed in place ; the channel, partly obscured by the harness, is to pass the parachute release box. An accelerometer is carried in the space immediately in front of the pilot

---

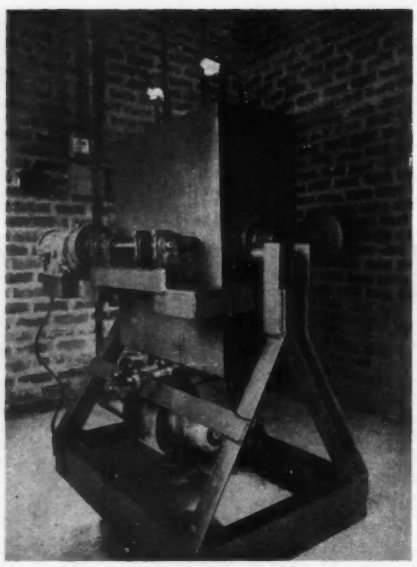
AIRBORNE LIQUID OXYGEN EQUIPMENT.—In January this year the first British aircraft to carry a liquid oxygen system, a " Meteor " N.F.11, commenced flight trials of an installation by Normalair, Ltd., Yeovil. A 5-litre liquid oxygen converter provides a supply equivalent to that of six 750-litre gas cylinders and reduces to one-third the weight, and to one-fifth the space, required. The oxygen container is kept at a pressure of about 70 lb per square inch by evaporation in a coil below, but connected to the top and bottom of, the bottle : a valve in one of the intervening pipes closes when the desired pressure is reached. Another evaporating coil supplies gas to the pilot's oxygen demand valve. When the system is to be replenished a vent valve must be opened before the hose of the ground charging trolley can be connected. A capacitance type contents gauge visible on the outside of the fuselage is provided. The trials have been carried out at altitudes of up to 40,000ft and will be continued with pressurised " Canberra " B.2 aircraft. The equipment is at present in production for Republic F-84F " Thunderstreak " fighters.

Corrosion Resistant Lining for Ships' Oil Tanks

THE corrosion of the steelwork in the oil cargo compartments of oil tankers has long been a problem for which a solution has been sought. Research has been active in recent years to develop some method by which the corrosive attack can be eliminated or retarded and so relieve the shipowner of the very heavy costs incurred by repairs and maintenance.

A firm of chemical engineers, Prodorite, Ltd., of Eagle Works, Wednesbury, has been producing for a number of years a synthetic resin known as " Prodor-Glas " for application as a corrosion-resistant coating to metal tanks and other equipment. Although this lining has proved satisfactory, research has continued in the development of coating materials and the latest additions to existing products are " Prodorfilm," which is a polyurethane resin, and a liquid " Neoprene," which is a synthetic rubber coating. Some time ago a grade of " Prodor-Glas " and " Prodorfilm " was developed for the lining of fuel tanks; however, since " Prodor-Glas " required stoving at a comparatively high temperature for its polymerisation " Prodorfilm " was used. This is a cold setting material which polymerises by chemical reaction so that it is suitable for application where stoving is not possible

The " Prodorfilm " lining consists of a series of coats of lacquer applied at intervals over a priming coat. To give good adhesion it is essential that the steelwork is thoroughly cleaned and scale removed by shot blasting or other

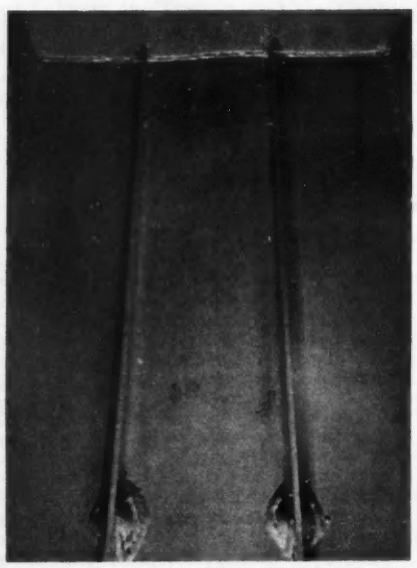


Apparatus for making accelerated corrosion tests

methods before the application of the primer, which is rust-inhibiting, as are also the first coats of the lacquer. " Prodorfilm " has to be mixed daily and successive coatings are applied to give a lining having a final total thickness of 0·005in. When applying the lacquer it is suggested that the temperature should not be less than 50 deg. Fah. and not more than 90 deg. Fah., and that about eight hours should be allowed between the application of coats to allow for curing. It is of interest to note that the material is not liable to embrittlement.

" Prodorfilm " has been applied to the refined edible oil tanks of the merchant ship " Freya Torm," and has given good service since 1953. The material has also been used to line the fuel oil tanks of H.M.S. " Grey Goose," H.M.S. " Bold Pathfinder," and H.M.S. " Bold Pioneer," while in 1954, to provide a more practical test, the upper surfaces of two cargo tanks of the " Athelmere " were lined. These tanks normally carry warm molasses or sea-water ballast and " Prodorfilm " was applied to the underside of the upper deck and to the upper 10ft of the boundary bulkheads. The lining has been inspected at intervals during the past two years and is reported to be in good condition.

Purely practical trials involve a long interim period, although each succeeding year of successful service does suggest that those years can be added to the life of the structure. This confers some economic advantage in that the ship continues in service for a longer time before repairs are required. However, to advance the knowledge of the performance of " Prodorfilm," as a lining for ship tanks under the arduous conditions of service encountered at sea, a test apparatus was specially designed by Sir Joseph Isherwood and Co., Ltd. The apparatus consists of two small tanks, one lined with " Prodorfilm " and the other being unlined, equipped so that the actual service conditions obtaining in an oil cargo tank could be simulated. These conditions included the filling of the tanks with crude and refined oils and sea-water and washing down with hot salt water to a test schedule, while the tanks were given a rolling motion and the structure stressed by causing part of it to deflect in a manner similar to that of the longitudinal and transverse bulkheads of a ship.



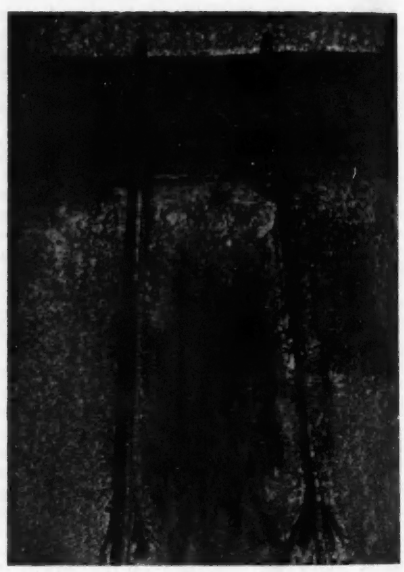
Condition of "Prodorfilm" lining after cycle No. 9

Our illustration gives a general view of the test apparatus which consists of an enclosed rectangular tank having welded stiffeners and divided by vertical partition to form two compartments measuring 1ft 3in by 1ft 3in by 3ft. An electric drive causes the combined tank to oscillate through 10 deg. each side of the vertical at a rate of 30 cycles per minute. Another drive operates two cams which cause one side of each tank to deflect a total of ½in so that the plating is stressed both in compression and tension beneath the lining. An ullage of 6in is maintained and provision is made for bubbling air at pressures up to 5 lb per square inch through each tank. Inspection plates permit the interior surfaces to be inspected and photographed. The welding of the structure was intentionally left in a rough state so that surface conditions approximated more nearly those encountered in practice.

The interior surface of the tank to be lined was cleaned by shot blasting and then sprayed with a primer; after this four coats of " Prodorfilm " lacquer were applied by brush, namely, yellow, red, grey and red lacquers in that order. No special treatment, such as additional coats, was accorded to the welds, tank corners and stiffeners, and the final thickness of the lining was between 0·005in and 0·006in. As already mentioned, a special test schedule was carried out in which the contents of the tanks were generally similar to those which the ship would normally expect to carry when trading. The cycle of operations is set out in the following table, the sea-water, which was synthetic and was freshly prepared for each cycle, consisting of sodium chloride 30 parts, anhydrous magnesium sulphate 2 parts, anhydrous magnesium chloride 3 parts, and tap water 965 parts by weight:—

Cycle No.	Contents of tanks	Time under test (hours)
1	Iraq crude oil	96
2	Sea-water	96
3	Kuwait crude oil	96
4	Hot sea-water at 178/160 deg. Fah.	2
5	100/130 octane aviation spirit	96
6	Sea-water	97
7	100/130 octane aviation spirit	96
8	Hot sea-water, 185/170 deg. Fah	2
9	Turbo-jet fuel	96
10	Hot sea-water, 187/172 deg. Fah	2
11	Venezuelan crude oil	95
12	Cold Venezuelan crude oil, 38/52 deg. Fah.	94
13	Hot sea-water, 186/168 deg. Fah.	2
14	Iraq crude oil	96
15	Sea-water	97

As a result of the tests it was observed that the unlined compartment suffered an increasingly severe corrosive attack, particularly the underside of the top surface and over the sides at and above the level of the test liquids. In contrast, the " Prodorfilm " lining remained not only intact, but retained its original gloss. No sign of breakdown or corrosion was observed, and there was no evidence of any cracking of the lining due to the panting movement of one of the tank sides. The photographs which we reproduce give interior views of both tanks and show their condition after the completion of cycle No. 9.



Condition of interior surfaces of unlined test tank after cycle No. 9

HIGH DENSITY " ALKATHINE."—A high density, stiff " Alkathine " which has been developed by Imperial Chemical Industries, Ltd., can be used for making injection-moulded or extruded articles which can be heated for sterilising purposes without distortion for up to fifteen minutes at 110 deg. Cent. This new polythene, to be known as " Alkathine HD," is made by a modification of the high-pressure process; its improved strength, stiffness and heat-resisting properties make it particularly suitable for use in making mouldings and pipes, for cable insulation purposes and for film.

Oil Refining in Australia

By V. S. SWAMINATHAN, M.A., M.Sc.

No. II--(*Concluded from page* 283, *March 30th*)

Since the war the oil refining capacity of Australia has been expanded considerably, with the addition of new units to existing plant and the construction of new refineries at Altona, Geelong, Kurnell and Kwinana. The new and enlarged installations are expected to refine about 80 *per cent of Australia's consumption of petroleum products in* 1956.

THE Kwinana refinery, of which a number of photographs are reproduced, was designed to combine operational efficiency with the minimum of capital outlay. Thus all pumps are out in the open, and equipment such as heat exchangers, condensers, and coolers, has been brought down to ground level with a corresponding reduction in the tonnage of structural steelwork used, and improvement in access for maintenance purposes. A substantial measure of functional grouping has been achieved in that each distillation unit has its own solutizer, while the Hydrofiner and Platformer share a common control room. The layout has been made as compact as possible to reduce the initial outlay on services, but it is capable of easy future expansion.

Before operations could begin on the main port structure in June, 1953, a 550ft long construction jetty had to be built out of rubble. Then steel piles and precast concrete beams were carried on a railway line laid to the head of the jetty, and thence by barge to the tanker jetty site. Pile drivers drove the piles into the sea bed, and on top of them the massive concrete beams and planks were laid. Towards the end of 1954 the steel and concrete tanker berthing jetty built on Cockburn Sound was completed, and the first tanker berthed the following January. This job called for the use of nearly 1000 box piles and 26,000 tons of concrete. The jetty is L-shaped, the short leg being a 1000ft arm running out from the shore into Cockburn Sound, the longer leg forming an 1800ft long sea arm. The sea arm was built in 20ft of water, but, to provide the depth needed by large tankers, three short berths stand further out in water 40ft deep at low tide. These short berths, parallel to the sea arm, are linked to it by concrete decking and pipe bridges. They are capable of taking the largest tankers operated by the British Tanker Company, Ltd.

A small fleet of vessels were engaged in the work of building the jetty, including two pile driving pontoons, two large barges and four crane pontoons, employed to lift steel piles into position for the pile drivers, shipped from Britain. A yard was established ashore for the precasting of concrete beams and decking in steel moulds. Prior to this, however, hollow steel piles, each weighing several tons, and some 100ft long, were driven deep into the sea bed and accurately sited, so that the subsequent placing of the cross beams and concrete decking was relatively simple. High-tensile bolts, which were stretched by a patented pull-jack exerting a 42-ton pressure as they were tightened into position, locked the structure together. From the face of each of the three berths protrude sixteen steel shock-absorbing fenders faced with hardwood. They are about 3ft in diameter and have behind them a solid 2ft cylinder of rubber. Before being driven all piles were coated with bitumen, but this protective film proved inadequate and was reinforced by the installation of a cathodic protection system, using magnesium anodes. Pipelines have also been treated to protect them from corrosion.

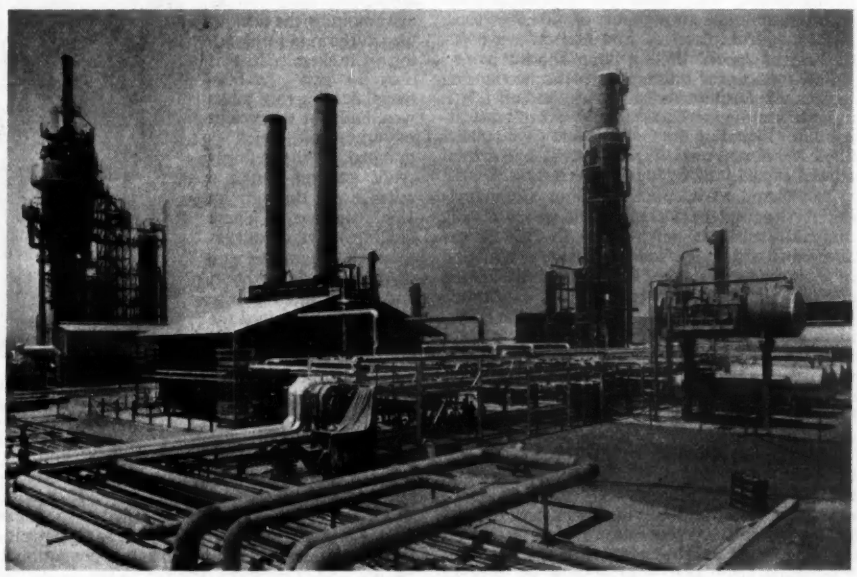
Work on port facilities began in January 1953, and operating on behalf of the State Government two Dutch suction dredgers began to widen and deepen the approach channel, with a total length of 4½ miles, through the Success and Parmelia sandbanks. By October 1954, they had removed over 5,000,000 cubic yards of sand and deepened the channels to 34ft, sufficient to allow medium size tankers to enter the Sound, but, to provide sufficient clearance for 32,000-ton vessels, deepening has been continued to 38ft, and to a maximum width of 500ft at the bottom. The complete operation called for the removal of 7,500,000 cubic yards of sand.

Late in 1954, the Kwinana refinery was connected to the Fremantle port by two high-pressure products pipelines. Work on the trenching and laying of the lines was started early in the year and products from the Kwinana plant began flowing through them early in 1955. One pipeline, 12in in diameter and 15 miles long, carries fuel oil to ships' bunkering stations at Fremantle harbour. The other, a 6in diameter line 17 miles long, crosses the Swan River and terminates at a distribution depot. White oils for distribution throughout Western Australia are pumped through this line. The 12in line, with its two duplex double-acting, steam-driven ram pumps, was designed to transfer about 400,000 tons a year of black oils. Heat lost to the ground from the lighter black products, which are pumped hot, is utilised to reduce the heat loss of the heavier oils to follow. The white oil line, to which motor driven centrifugal pumps are attached, was designed to transfer approximately 550,000 tons of products per annum. These two lines were laid side by side, and lie buried beneath 4ft to 12ft of earth and rock, their route generally following that of the proposed main highway on which work was started last year. It links the new townships and the refinery with Fremantle and Perth, and will have two main 35ft carriageways, each with three traffic lanes.

The pipelines were tested at every stage of construction. Their 40ft lengths were seamless, solid drawn pipes specially fabricated for the job. The 6in line was manufactured locally and the 12in line in Britain. As a protection the pipes received a coating of bitumen enamel followed by a wrapping of glass fibre, also a second, and tougher, wrapping of asbestos and glass fibre impregnated with asphaltic pitch. Provision has also been made for cathodic protection for the pipelines if deemed necessary.

A mobile X-ray unit checked each welded joint in the line. Built at Kwinana this unit employed up to 120,000V in its oil-cooled X-ray tube and took three photographs of each welded joint. Faulty welding was cut out, the pipe edges were re-bevelled and a new full-circle weld made. The long lengths of welded sections were handled into their trench by sideboom tractors; however, before the pipes were laid testing was carried out. First, a "pig," consisting of a series of rubber discs and wire brushes, was passed through the sections to remove internal rust, stones and even small animals which may have crawled into the piping. Later, the sections were sealed at either end, and subjected to air and water pressure tests, the water being removed by another "pig" and the line made ready to receive the first flow of refined oil products.

With the commissioning of the Kwinana refinery there has been a great advance in Western Australia's industrial potential. It is anticipated that in about three years' time, this plant, coupled with other undertakings expected to settle in its environs, will increase the State's total production income by £A.40,000,000, equivalent to one-fifth of its 1951-52 figure. In its endeavour to attract new enterprises Western Australia sells sites cheaply, gives free technical assistance, guarantees bank finance to approved projects, and is prepared to sponsor applications to the Commonwealth Government for duty-free imports of machinery, equipment, &c. In addition to the Broken Hill rolling mill and the Cockburn Cement Works, negotiations are under way for the erection of a tube works by Stewarts and Lloyds, Ltd., of Britain. The State Government has plans to expand the Medina District into a model city of 40,000 people to house the families of those who will man the factories for which sites are available along the shores of the Cockburn Sound.



"A" Topping unit at the Kwinana refinery

On March 18, 1954, Field-Marshal Sir William Slim, Governor General of Australia, formally opened the first of the Commonwealth's major refineries operated by Shell Refining (Australia), Pty., Ltd., on the shores of Corio Bay near Geelong, some 40 miles from Melbourne in Victoria. This ceremony signified the completion of the first stage of the project, the commissioning of the crude distillation unit with an annual throughput of 1,750,000 tons of oil. The second stage of construction, the installation of a fluid catalytic cracker, to convert part of the heavy petroleum fractions obtained by crude distillation into high-grade motor spirit, was completed last year.

Shell's Geelong refinery is built on a 250-acre site, and crude stock for processing comes mainly from sterling sources, Seria oilfields in British Borneo, and the Middle East. The tank farm consists of thirty-four storage tanks with a combined capacity of 200,000 tons, and the refinery products are pumped from Geelong to Melbourne through a 6in diameter pipeline, 36 miles long, which was completed in 1954. It has an estimated maximum throughput of 225 million imperial

gallons a year, a figure which it would be possible to step up to 600 million gallons annually by the provision of an auxiliary pumping station. Both petrol and diesel oil are pumped through this line, intermixing being avoided by pressure control. To facilitate the rapid handling of incoming cargoes of crude oil the Geelong Harbour Trust have dredged the port approaches to a depth of 32ft, and built an oil jetty capable of accommodating tankers up to the size of the Shell Group's new 18,000 tons deadweight general-purpose vessels.

Construction work on the fluid catalytic cracker, with an annual intake capacity of 650,000 tons, was started early in 1954. This installation includes a feed preparation unit, to make feedstock for the catalytic cracker proper, and a polymerisation unit for converting a portion of the catalytically cracked gases to high-grade petrol. At the completion of this second stage of the project Geelong's tankage consisted of some sixty storage tanks with an aggregate capacity of 400,000 tons. The refinery has an annual capacity of 610,000 tons of motor spirit, 580,000 tons of distillate and diesel oils, and 380,000 tons of furnace oil.

Shell's first refinery in Australia at Clyde, New South Wales, part of which is illustrated, was bought in 1927 from John Fell and Co., and consisted of a crude distillation unit and auxiliary plants, covering 62 acres, producing petrol, power kerosene, diesel fuel and fuel oil. In 1935 a solvent still was erected, two years later a modern topping plant was added, and the bitumen plant, built at this refinery after the second world war, is one of the most up-to-date in the world. Here Shell has a topping plant with an annual throughput of 408,000 tons, yielding petrol, diesel oil and fuel oil ; a 6000-tons-a-year special boiling point solvent plant ; a 6000-tons-a-year bituminous plant, accounting for gas oil, distillate and bitumen, and an L.V.I. unit accounting for 72,000 tons a year of lubricating oils. Including the Geelong and Clyde plants Shell Refining (Australia) Pty., Ltd., has a total annual capacity of 2,250,000 tons.

The Standard-Vacuum Refining Company's initial Altona plant started producing lubricating oils and asphalt in July, 1949. In 1952 it was decided to extend its facilities for the production of high-grade motor spirit and fuel oil with the addition of a 25,000 barrels per day crude distillation unit, and a Thermofor catalytic cracking (T.C.C.) unit, illustrated herewith, with a feed capacity of 19,000 barrels per day. These were commissioned early in 1955. Further additions to the refinery already decided upon are an alkylation plant, and a Sovaformer catalytic reformer.

The original Altona installation consisted of a combination crude unit producing light naphtha, heavy naphtha, diesel fuel oil, three grades of once-run lubricating oil distillates and several grades of asphalt. The once-run lubricating oil distillates were acid treated in regular acid and neutralising agitators and re-run in a small pipe still operating at the rate of 600 barrels per day. These oils were run in the presence of caustic soda and bright marketable lubricating oils in three different viscosities were taken from the side streams. This unit was operated to give minimum bottoms containing all the caustic soda, the material being a mixture of 40 per cent soap and 60 per cent hydrogen. This soap was broken in a de-ashing agitator and the de-ashed re-run bottoms were utilised as boiler fuel. The lubricating oils were blended to give a considerable number of viscosity specifications, and shipped to all parts of Australia and New Zealand in 45-gallon steel drums.

Asphalt was delivered both in drums and in bulk in insulated road wagons taking the hot material direct to the road building site. For greater distances hot asphalt was transported in rail tank cars. The road wagons were found to have a highly economical operating radius up to 120 miles.

The Altona property covers 300 acres on a level site nearly 5 miles from the deep water port of Williamstown, and about the same distance from the marketing company's bulk distribution installations. It was found necessary to reconstruct one of the main docks at the port and erect some transit tankage adjoining the dock to hasten the rapid unloading of tankers. In this section two 120,000-barrel floating roof tanks were built for the receipt of crude oil which is pumped to the refinery crude storage tanks 5 miles away through an 18in pipeline. These facilities permit tankers to discharge at the rate of 7000 barrels per hour, and it is planned to use super-tankers to feed the Altona plant with crude oil.

Process design of the enlarged facilities was undertaken by the Refinery Engineering Division of Socony Mobil Oil Company, Inc., and the contract for the mechanical design and construction of the entire plant was let to C. F. Braum and Co., of Alhambra, California. The new Altona installation consists of a 25,000-barrels-per-day crude distillation unit of conventional design, and a naphtha splitter tower to divide the overhead into light and heavy fractions. The lighter naphtha is used in the blending pool, and the heavy naphtha as catalytic reformer feed.

Bitumen refinery plant at the Clyde refinery, showing blowing and vacuum distillation columns

Oil tanker berthing jetty at Kwinana

The crude unit produces the required quantities of automotive diesel oil, while all the heavier fractions go to feed the T.C.C. unit, which has a feed capacity of 19,000 barrels per day.

The T.C.C. unit is the first of its kind to be built in Australia. Here the regenerated catalyst is blown by air through a pipe more than 200ft high to the top of the reactor, the air replacing the mechanical methods of lifting the catalyst employed in earlier designs. The catalyst then flows from the top of the pipe under gravity. The new unit possesses the advantage of simpler and easier operation, combined with greater flexibility, enabling a wider range of stocks to be handled. It increases both the quantity and quality of petroleum products, in particular motor spirit.

Heavy oil from the crude distillation unit goes first to the T.C.C. feed preparation unit, consisting of a tar separator and vacuum jug, tar from the former furnishing the feedstock of the latter. This catalytic cracker takes both vapour and liquid feed, the vapour from the tar separator passing direct to the T.C.C. reactor, while the liquid feed is taken from the vacuum jug. The bottoms from the vacuum jug go to heavy fuel oil, or are worked up into asphalt. The T.C.C. unit makes gas, petrol, diesel fuel oil and heavy fuel oil. The gas is compressed by a single Carrier centrifuge compressor driven by a Westinghouse turbine, while gas and petrol are treated in conventional absorber and stabiliser towers.

Part of the gas is used as refinery fuel and a large quantity is sold to the local Gas and Fuel Corporation and blended with domestic gas to improve its calorific value. The Mobil Oil Company has built a gas desulphurisation unit which also dries the refinery gas before it passes into the Gas and Fuel Corporation pipeline, and which operates on monoethanolamine and diethylene glycol.

Petrol from the distillation and T.C.C. units is treated in a solutizer plant for the control of corrosive sulphur and later sent to the blending

Thermofor catalytic cracking unit with naptha splitter tower on the left and crude tower on the right

section, consisting of a series of tanks and a modern ethyl blending unit. The crude distillation unit also produces jet fuel, which is treated in a copper chloride sweetening plant in the light oil treating area. Three 6in pipelines carrying respectively heavy fuel oil, middle distillates and petrol, convey the products to the marketing company's bulk distribution installations. The refinery produces annually 380,000 tons of motor spirit, 240,000 tons of distillate and diesel oil, 200,000 tons of furnace oil, and a small quantity of jet fuels.

The cooling water arrangement for the plant was originally designed as an " all loss " system, salt water being pumped from an adjacent creek ; but, following the installation of additional facilities, this has been altered into a totally enclosed system and a five-cell Marley cooling tower has been built. Two 70,000 lb Riley boilers have been added to the power plant, also new machine shops, and a well-equipped laboratory.

Crude oil for the pioneer Altona installation was drawn from Venezuela, but about five years ago suitable raw material was obtained from the new Klamono field in N. W. New Guinea, a nearer source of supply. For the enlarged plant crude oil supplies come from the Persian Gulf, and another relatively new field, Wasian Mogoi, in New Guinea. These oils are stored separately and blended in the feed line to the distillation unit.

Further additions to the Altona refinery, already decided upon, include a Sovaformer catalytic reformer, and a sulphuric and alkylation unit. The first unit is scheduled to go on stream by mid-1956. The basic alkylation plant will have an annual production capacity of 20,000,000 Imperial gallons of high-octane aviation spirit, and when in full operation will result in a saving in foreign exchange to Australia of 3,600,000 dollars. The 15,000 tons of sulphuric acid required to operate the alkylation plant is to come from the factory of the Commonwealth Fertilizers and Chemicals, Ltd.

Lastly, Caltex, operating through Australian Oil Refining, Ltd., has constructed a fourth major plant having an annual throughput of 1,100,000 tons at Kurnell, New South Wales, at a cost of £A25,000,000. Before this location was chosen road and rail transport, utilities and marine accessibility formed special subjects of careful study. Site conditions for bearing heavy loads, labour transport, reception of material, laying of crude and product pipelines and availability of cooling water were also thoroughly examined.

The marine terminal facilities consist of a long wharf, together with a swinging basin which, on completion, will accommodate tankers having a draught of about 34ft. The construction of the wharf called for 2000 tons of steel, 3000 tons of cement and the dredging of 2,000,000 cubic yards.

The Kurnell refinery has a two-stage distillation unit, a propane decarbonisation unit, an up-to-date fluid catalytic cracker, and a complete steam and electricity generating plant. It will produce annually 540,000 tons of motor spirit, 20,000 tons of kerosene, 120,000 tons of distillate and diesel oil, 170,000 tons of furnace oil, as well as jet fuels, and its permanent employees will total 300 to 350 persons.

Table I gives a summary of Australia's oi refining progress.

TABLE I

Company	Refinery location	Barrels per stream day		
		Crude distillation	Catalytic cracking	Thermal operation
Australasian Petroleum Refinery, Ltd.	Kwinana[1]	70,000	12,500	—
The Shell Refining (Australia) Pty., Ltd.	Geelong[2]	36,000	—	—
	Clyde	8,400	—	—
Standard-Vacuum Refining Company, Ltd.	Altona[3]	2,200	9,200	5,200
Australian Oil Refining, Ltd.	Kurnell[4]	22,000	13,000	—
Bitumen and Oil Refineries (Australia), Ltd.	Matraville[5]	6,500	—	—
Commonwealth Oil Refineries, Ltd.	Laverton	4,200	—	—
		149,300	34,700	5,200

[1]Atmospheric distillation plant consists of two 35,000 bbl. units ; special processing units embrace 13,900 bbl. vacuum distillation, 6000 bbl. platformer, and 5600 bbl. hydrofiner. Asphalt production 20,000 long tons a year.
[2]A 12,000 bbl. fluid catalytic cracker commissioned in 1955.
[3]Early in 1955, 27,000 bbl. crude distillation capacity added ; catalytic cracker and reformer plants went on stream last year. Special processing units include 670 bbl. lubricating oils, and 2200 bbl. vacuum distillation.
[4]Completed last year ; special processing units include 13,900 bbl. vacuum distillation unit, and 1450 bbl. polymerisation unit.
[5]Added in 1955 a 10,000 bbl. atmospheric distillation unit, as also a 900 bbl. platformer and 2300 bbl. catalytic hydrogenation plant.

In conclusion, with the continued rapid growth in industry and transport, Australian demand for motor spirit, diesel oils, furnace oils and bitumen has increased, and the greater employment of mechanical appliances and tractors by the local farming industry has reinforced this trend. Oil imports into the Commonwealth were of the order of 2,000,000 tons in 1936, whereas the consumption of petroleum products in 1956 is estimated to be not far short of 8,000,000 tons. Australia offers a rapidly expanding domestic market for petroleum products, and the new and enlarged refinery projects confer a greater continuity of supplies of liquid fuel products. From meeting barely 15 per cent of national needs in 1953, the new and enlarged installations will refine approximately 80 per cent of Australia's consumption of petroleum products in 1956.

TABLE II

Australia's Estimated Production and Consumption of Petroleum Products in 1956 *(in Long Tons)*

	Production	Consumption
Motor spirit	2,590,000	3,200,000
Kerosene	220,000	550,000
Distillate and diesel fuel	1,295,000	1,850,000
Fuel oil	2,041,000	1,700,000
Other products	400,000	600,000
Total	6,646,000	7,900,000

Load Simulator for Railway Formation Materials

A TESTING machine has been designed and constructed in the soil mechanics section of British Railways, Western Region, to simulate the action of a train passing over a sleeper. It consists, essentially, of three main parts, namely, a cage, free to move in a vertical direction, with a platform at the bottom carrying a bearing pedestal ; a test box, 2ft 6in by 2ft 6in by 1ft, with an arrangement for increasing the height by 6in, in which samples of track formation are placed ; a concrete foundation supporting a rigid framework with rods at the corners to guide the vertical movement of the cage.

The cage transmits the load to the sample in the test box through the bearing pedestal, which remains in contact with the sample throughout the test ; its rate of movement is varied by eccentric flywheels rotating in opposite directions and driven by a 2 h.p. motor bolted to the platform. For the tests mentioned below, the impact load varied between zero and 3000 lb, equivalent to 5·3 tons per square foot ; the rate of application was 340 blows per minute and the area of the bearing pedestal 36 square inches. One hour's running of the impulse loader represents five days' running of trains, assuming 4000 axle loads per day.

To assess the value of a blanket of stone dust in preventing " slurrying," tests were carried out with both Old Red sandstone and Keuper marl, as the formation material, with and without a layer of stone dust between the formation and chippings. It was thus demonstrated that a 6in layer of stone dust was effective in preventing slurrying.

Waterproofing Additive for Concrete

A LIQUID which can be added to a concrete mix to increase the watertightness of the concrete, known as " Bitucrete," is now being produced by the British Bitumen Emulsion Company, Ltd., Slough, Bucks. This product has been used fairly extensively in the United States, under the name " Hydropel " ; apart from its waterproofing properties, it is claimed to have other advantages, such as giving increased workability, less segregation of aggregates, and resistance to attack from sulphates in ground water. The maker states that in reinforced concrete " destructive internal stresses due to the volume change of ordinary concrete unprotected from moisture," can be effectively reduced by use of the additive. Two methods of water absorption are postulated—by capillary action and by immersion. Tests were carried out with standard mixes, we are informed, in which, after curing, cubes were immersed for seven days in water ; those without the " Bitucrete " additive absorbed 3·1 to 6·1 times as much water as the others. A test for capillary absorption gave 4·3 to 7·4 times as much absorption without the additive.

Continental Engineering News

The West German Air Force

Under the agreements made at Paris, the Air Force of the German Federal Republic is to attain its full strength by January 1, 1960. It will then consist of twenty wings, totalling 1236 first-line aircraft, and some 100,000 men, including civilian personnel. Since under the Treaty the West German Air Force is to serve tactical purposes only, it will have no heavy bombers. It is to consist of the following formations :—Four wings of fighter aircraft, eight wings of fighter-bombers, three wings of reconnaissance planes, three wings of all-weather fighters, and two wings of transport planes. Each wing will have from thirty-six to seventy-five planes, and will be organised in three squadrons. Fighter and fighter-bomber wings will comprise seventy-five planes, reconnaissance wings fifty-four, transport wings forty-eight planes, and the all-weather wings thirty-six planes each. All planes other than transports are to be jet-propelled. In addition to first-line aircraft, more than 2000 auxiliary aircraft will be required by the German forces as a whole for communication, artillery spotting, and similar purposes.

As the build-up period will be devoted mainly to the training of flying and technical personnel, it is not considered a matter of the foremost importance whether or not all of the aircraft initially are of supersonic design, but for reasons of economy and logistic simplicity it is desired to obtain as much uniformity of equipment as possible. With this point in mind, officials look above all to the United States, which promised an unspecified portion of the initial equipment under the foreign aid programme. The following aircraft are stated to be most suitable :—The " F84F " fighter-bomber, the " F86K," or, better still, the " F102 " all-weather fighter, and the " RF84F " reconnaissance aircraft. Consideration has also been given to the Hawker " Hunter " and the French " Super Mystère."

The view that the new air force need not be equipped with supersonic aircraft applies to the initial period only. Thereafter, it is generally held, the very best designs should be made available. It is thought that the Western nations should pool their technical resources for the purpose of producing aircraft best fitted to European conditions. In view of the relatively short distances in Western Europe, the required planes must be as light as possible to achieve maximum rates of climb, a performance of some 60,000ft in two minutes being the aim. It is realised that this a stringent demand, particularly with regard to the all-weather fighters with their heavy electronic equipment. As far as armament is concerned, German experts believe that rockets equipped with homing devices hold the future.

It is not considered that a programme of such magnitude and intricacy could be carried out by any single country, nor that the attempt should be made by the German Federal Republic for the sake of prestige. The reconstructed German aircraft industry is, for the time being at any rate, to concentrate on the repair of aircraft and the construction of certain foreign designs under licence. In this connection, Messerschmidt A.G. and Ernst Heinkel A.G., which have joined forces, are to build the French jet trainer Fouga " Magister," while the Italian trainer " P149 " is to be built by Focke-Wulf Flugzeubau G.m.b.H., Bremen, in conjunction with the design office of Professor Blume at Duisburg. Meanwhile, the Federal Government has placed an order for seventy-five training aeroplanes, type " P149D " with the Italian firm, Piaggio of Finalmarina. The machine is a four-seater, powered by a Lycoming-GO480 engine developing 270 h.p., which is built in Italy under licence. Of other companies about to take up or resume aircraft construction, Dornier has developed the " DO27," a five-seater powered by a single 250 h.p. " Continental " engine. The German Defence Ministry is reported to have ordered 428 of these machines. The Nord G.m.b.H., formed out of the Blohm and Voss successor firm Hamburger Flugzeubau G.m.b.H., the Bremen company Weser G.m.b.H., the Siebel A.T.G., and Henschel and Sohn of Kassel, is planning to build the French transport Noratlas " NRD 2501," capable of carrying a 20-ton payload over a distance of 800 miles at 275 miles per hour.

A serious problem for the new German Air Force is that of training. With the draft period for the armed forces scheduled to last one and a half years, the Air Force will have to rely mainly on volunteers, since the training of airmen, including basic training, takes two years. There will probably be no difficulty with regard to pilots, but whether sufficient skilled technicians will be willing to sign on for any length of time is considered doubtful.

By the time the " Volunteer Law " expires at the end of March, some 600 German airmen will be in training, mainly at the four American air bases in Bavaria, and at Nörvenich, near Düren. During the initial stage, trainer planes will be furnished by the U.S. Air Force. Veteran pilots of the last war are believed to require about eight months to be trained on modern jet aircraft. Additional training for future flying instructors makes them the most expensive members of the armed forces, their cost, exclusive of pay, being estimated at DM.300,000 per head.

Compared with the German Federal Republic the German Democratic Republic has the advantage (which operates mainly with regard to training) of having started its air force two and a half years earlier, when air squadrons of the People's Police were first set up. These forces are reported to consist at present of three wings or " air divisions," each comprising two " air regiments." The first of these regiments in each case is equipped with " YAK 18 " fighters, and the second with " YAK 11 " fighters. The total number of planes is said to be 120 " YAK 18 " and 180 " YAK 11 " aircraft. While these planes must be considered antiquated, it seems likely that more advanced designs will be supplied under the Warsaw pact.

Supercharging Tests of a Diesel Engine

It was in 1951 that Nydqvist and Holm A.B., Trollhättan, Sweden, first started to work on the supercharging of their Nohab-Polar two-stroke, loop scavenging engines, a development which has continued since that time. The first tests were made on a three-cylinder " Model E " engine, of 180mm bore, 300mm stroke, and running at 600 to 700 r.p.m. At first the constant pressure system was used and the supercharger was connected in series with the directly driven scavenging pump, giving an increase in output of about 40 per cent. Later, tests were carried out on the same engine, using the pulse system, with and without scavenging pump. These tests are not yet completed.

In the autumn of 1954, tests were started on the supercharging of the Nohab-Polar " Model MN16 " engine. This engine is a development of the " Model M " design and has the same cylinder dimensions, i.e. bore 340mm, stroke 570mm. There are six cylinders and the engine speed is 300 to 375 r.p.m. In the " MN16," the cylinder distance has been reduced and the dimensions of the crankshaft have been increased. A new design of piston has been incorporated and the scavenging efficiency of the " M " engine has been increased still further ; at the same time, the scavenging pipe valves have been omitted.

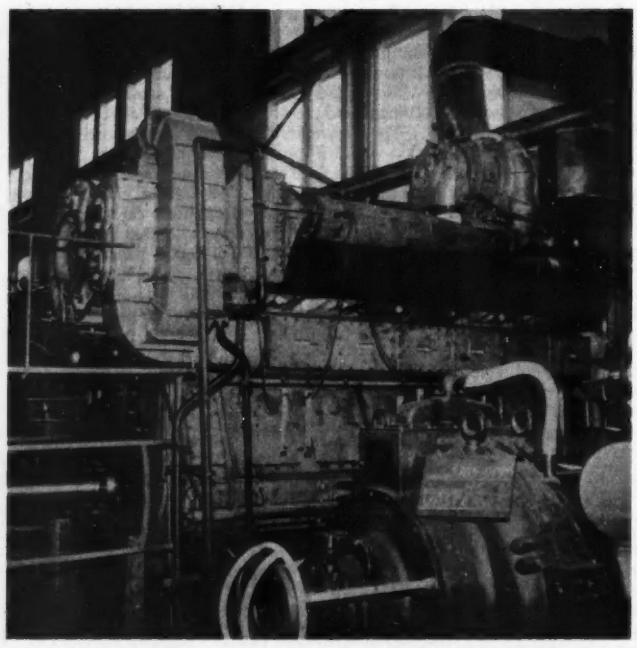


Fig. 1—Test of " MN-16 " engine with exhaust-driven supercharger and scavenging pump

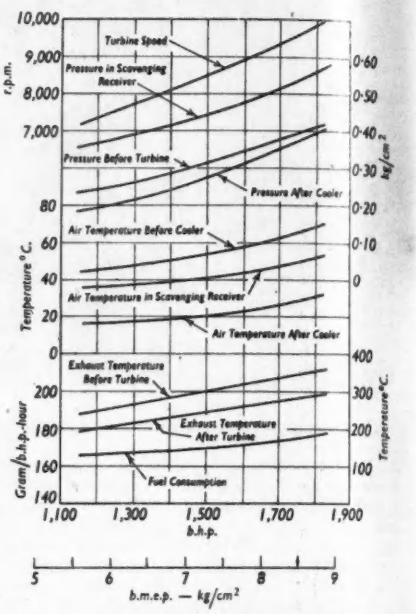


Fig. 2—Test results for supercharged and scavenged " MN-16 " engine

The first tests were carried out in the same way as those on the " K53E " engine, by using a constant pressure system. A Napier " IS400 " exhaust-turbine-driven supercharger was connected in series with the ring-piston scavenging pump of the engine (Fig. 1). Before entering the scavenging pump, the air from the centrifugal impeller of the supercharger was water-cooled.

Various loads were applied at speeds of 300, 335 and 375 r.p.m., results obtained at 300 r.p.m. being shown in Fig. 2. The maximum output so far obtained corresponds to brake mean effective pressures of 8·8 kg per square centimetre, 8·4 kg per square centimetre, and 7·0 kg per square centimetre, at the speeds mentioned. At 335 and

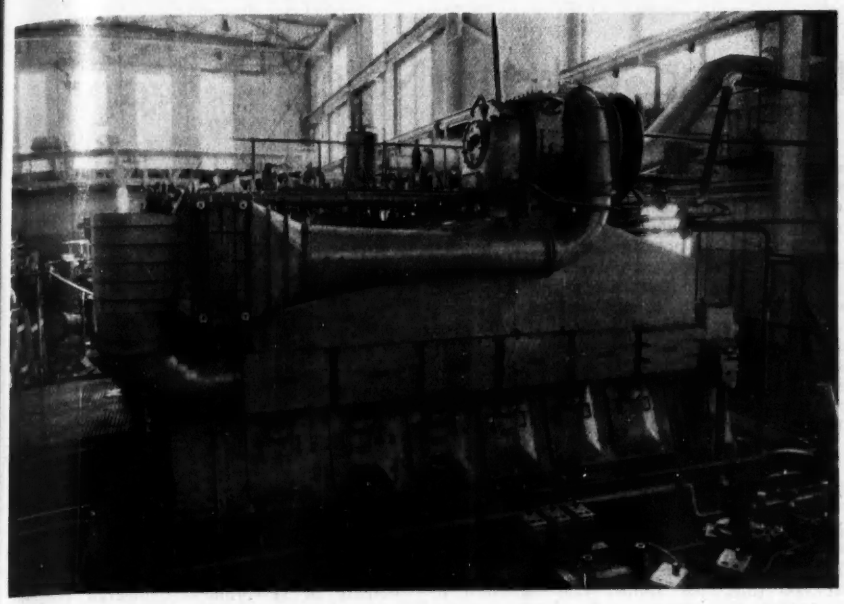


Fig. 3—Supercharger connected directly to air inlet manifold, with air cooler interposed

375 r.p.m., the power was limited by the maximum permissible turbine speed of 10,500 r.p.m. The exhaust gas was clear up to a mean pressure of 8·2 kg per square centimetre. Standard injection components were used, also two standard directly driven lubricating oil pumps, and standard directly driven pumps for cooling water or bilge. The lubricating oil cooler was of the same size as that of the non-supercharged " Model N " engines.

After 100 hours' running at 8·4 kg per square centimetre b.m.e.p., an examination was carried out of the engine pistons, cylinders, bearings and pins. No signs of overstrain of these parts by thermal or mechanical stresses could be observed.

On completion of this series of tests, experiments were started with a pulse drive system and without scavenging pump. The set-up was like that used in similar tests on the " K53E " engine. Separate exhaust pipes between engine cylinders and turbine were used, and the area of the ports was enlarged (Fig. 3). An electrically

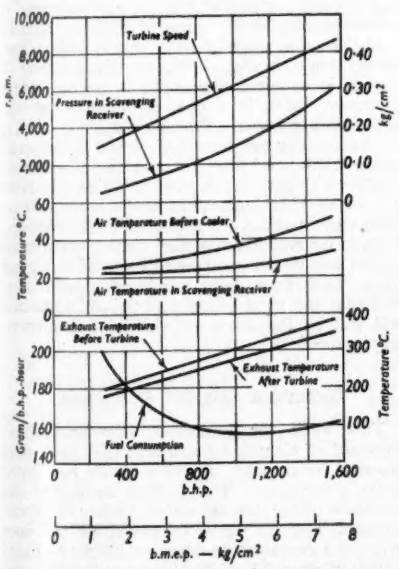


Fig. 4—Test results at 300 r.p.m. for pulse supercharging without using a scavenging pump

driven auxiliary scavenging blower of 6 h.p. to 8 h.p. was used for starting from cold, although cold starts at a room temperature of 20 deg. Cent. could readily be made without this blower. Manœuvring was just as good as on the normal engine without supercharging.

A series of tests were made at 300 and 335 r.p.m. Test data for the 300 r.p.m. runs are shown in Fig. 4. These curves show a considerably lower fuel consumption than that obtained with the constant pressure system and with the scavenging pump in series with the supercharger. Minimum fuel consumption was 156 grammes per horsepower-hour at 300 r.p.m., and 158 grammes per horsepower-hour at 335 r.p.m. The exhausts were clear up to 7·5 kg per square centimetre mean effective pressure. Due to the removal of the scavenging pump and its transmission the engine operated more silently than before. The ignition noise of the Nohab-Polar engine is stated to be small in any case owing to the use of pilot injection. Sound from the supercharger intake was also not considerable. The agent in the United Kingdom is Bolinders Company, Ltd., Coronation House, 4, Lloyd's Avenue, London, E.C.3.

Bibliography of Atomic Science and Technology

In its issue of February 1, 1956 (Vol. 98, No. 4), the V.D.I.-Zeitschrift publishes a bibliography of nuclear science and technology, comprising the following fields :—Physical fundamentals, chemistry of radioactive substances, metallurgy of fissile materials, reactors, stationary and mobile nuclear power installations, measurements and control of reactors, the application of isotopes in technology, and safety measures. A list of the principal journals and reports in this field is appended, together with abbreviations and sources of supply.

West German Coal Cartel Agreement

Following two years of negotiations with the German coal industry, the High Authority of the European Coal and Steel Community accepted on February 15th the proposals made for a reorganisation of the vetoed coal cartel Gemeinschaftsorganisation Ruhrkohle (Georg). From April 1st it is to be replaced by three independent sales organisations " Geitling," " Mausegatt " and " Präsident," each of which will represent coal mines from all parts of the Ruhr district chosen in such a way as to achieve a balance of grades and demand. Each will handle 15,000,000 tons of coal and 5,000,000 to 6,000,000 tons of coke per year. No overlapping of personnel between these organisations or their agents is to be allowed.

A joint office is to be established by the three organisations for supplying directly, if they wish, customers using over 50,000 tons per year and also the German Federal Railways. This office will hold stocks amounting to 22,000,000 tons, of which 10,000,000 tons are to be held on behalf of the Federal Railways, the object being to achieve flexibility with regard to the supply of different grades of coal, and to equalise the employment situation throughout the Ruhr coalfield. This office is empowered to take emergency measures. Its decisions and the operations of the three cartels are to be reviewed by an advisory body on which are to be represented the producers, employees in the Ruhr district and the consumers and coal merchants of the Community. Each of these groups will be represented by nine members, and the committee will meet three times a year, or at special meetings at the request of eight or more members. Both the High Authority and the Government can take part in these sessions. The advisory body cannot exercise control directly, which will be done solely by the High Authority itself.

A commission is to be set up by the Ruhr mining companies to decide on standards of own consumption, deliveries to the country, and equalisation of employment. It will have rationing duties in times of scarcity.

Lastly, the three sales cartels are to co-operate in the field of freight rates to Ruhrort, Antwerp and the Weser ports. Rates are to be pooled and no individual rebates or increases are to be allowed. Consumers can choose whether to buy f.o.b. or at pithead prices.

The cartels will deal with wholesalers who handle an annual minimum of 75,000 tons of coal from the Community, sell 40,000 tons Community coal in each of their respective districts, and take 12,500 or more tons from one of the cartels (instead of a total of 25,000 tons from all three, as requested by the Ruhr coal industry). This regulation will come into force in a year's time. Until then, the qualifying tonnage is to be 48,000 tons. Should more than ten wholesalers be eliminated by the 48,000-ton limit, the system is to be reviewed.

Sales districts are established from the standpoint of the Common Market instead of national considerations. There will be seven zones as follows :—Northern Germany and the Netherlands ; Ruhr district and Hannover ; Cologne, Belgium, Luxemburg, Trier ; Southern Germany, Saar, and France as far south as the Côte d'Or ; Northern France ; Southern France ; and Italy. Exports will be handled by a separate organisation. The new arrangements are to remain in force for three years, and may then be revised on application from the Ruhr coal industry.

International Automation Congress

The International Congress of Automation, organised by the Department of Mechanics of the Conservatoire National des Arts et Métiers, will take place in Paris from June 18 to 24, 1956. The congress is to be held under the auspices of the Ministry of Public Education, with the assistance of several scientific and engineering associations and the Association Française Pour L'Accroissement de la Productivité (A.F.A.P.). Automation is to be studied in its theoretical aspects as well as with reference to some of the scientific, technical, economical and psychological aspects which arise in practical applications. According to the preliminary programme which has been issued, there will be three sections, dealing, respectively, with General Automation, Applied Automation, and Automation and Production. At each session each section will meet to hear one main and three subsidiary reports, after which there will be a discussion. For some sessions, notably the introductory ones, the sections will combine. The official programme will end on June 22nd. In parallel with the Congress, an exhibition is being organised at the Conservatoire National des Arts et Métiers, by U.N.E.S.C.O. and A.F.A.P., at which films on automation will be shown continuously. There will be visits and a ladies' programme is also being arranged. Persons wishing to submit reports or communications should send the title and a brief summary to the secretariat before April 10th. Full details may be obtained from the secretary, " International Congress on Automation," Chaire de Mécanique, Conservatoire Nationale des Arts et Métiers, 292, rue St.-Martin, Paris (3e).

Industrial and Labour Notes

Economic Concern

Since we were last able to publish these notes, in our issue of February 10th, there has been considerable concern expressed in all quarters about the country's economic situation. The Bank rate, at 5½ per cent, is now higher than at any time since 1931, and certain other measures to counter inflation have been put into effect. The economic situation has been debated in Parliament, and more recently the Prime Minister and other Members of the Government have had talks with representatives of the British Employers' Confederation, the Federation of British Industries, the Trades Union Congress, and the nationalised industries on various aspects of the economic situation.

Last week, the Government's *Economic Survey*, 1956, was published. It is a document which brings together most of the information on economic matters which has been published in the last few months. A great deal of the information comprises a review of 1955, when there was a substantial rise in fixed investment. As to this year's prospects, the survey says that the course of economic developments will depend on the speed with which the disinflationary measures taken by the Government overcome the existing momentum of the boom. The survey goes on to say that, although consumers' expenditure constitutes by far the largest part of total demand, the main expansionary force in the economy at the present time is the increase in fixed investment in industry. Large programmes of modernisation and development are in hand in most branches of industry, both private and public, and these will in time greatly improve the country's productive capacity. But, the survey comments, at present this growth of investment, added to a rapid increase in stock-building, is imposing a strain on the economy, and is claiming too large a share of those kinds of industrial production which are most in demand in foreign markets.

The survey adds that "a high rate of productive investment remains an important national objective." Other demands on our resources must be restrained to make room for a higher rate of home investment and an improvement in the balance of payments. The survey therefore emphasises that "the aim of economic policy throughout this year will be to limit home demand, so that more of our production can be exported, and so that the growth of imports is moderated."

Overseas Trade

The statistics on Britain's overseas trade, which are issued monthly by the Board of Trade, show that with exports valued at £257,900,000, re-exports at £14,200,000, and with imports valued at £346,300,000, the visible trade deficit in January was £74,200,000. That was £2,000,000 above the monthly average for last year.

The value of exports recorded in February was £246,100,000, the decrease compared with January no doubt being accounted for by the fact that there was one working day less. The average value of exports over the two months, however, at £252,000,000, was 4½ per cent higher than in the corresponding period of 1955. Imports during February were valued at £309,100,000, which was £37,200,000 below the January figure. The average value of imports over the first two months of the year, at £327,700,000, was 2 per cent higher than in the comparable period last year. Re-exports in February reached a value of £13,500,000. The excess of imports over total exports was thus down to £49,500,000, the lowest visible deficit recorded since May last year.

The Board of Trade has said that, during the last four months, there has been little apparent change in the rate of exports when allowance is made for differences in the number of working days in the various months. Compared with the period November, 1954, to February, 1955, export prices over the last four months have been about 4 per cent higher, but in terms of volume the increase was not substantial. In the first two months of this year, however, engineering products continued to form a growing proportion of the total exports, being 9½ per cent above the corresponding period of 1955, despite a decline in motor-car exports. According to the Board of Trade's survey, there were striking increases in January and February in exports of aircraft, commercial vehicles, electrical machinery and textile machinery.

Iron and Steel

The British iron and steel industry maintains its high production rate. In January, steel output was at an annual rate of 21,069,000 tons, and in February, with an average weekly production of 417,800 tons, the annual rate increased to 21,724,000 tons. Pig iron output in January was at an annual rate of 13,558,000 tons, which figure increased in February to 13,692,000 tons.

For both pig iron and steel, production was at a higher rate in February than in any month previously. The high level of output maintained in recent months has led to a review of the production possibilities during the current year. After consultation with the industry, the Iron and Steel Board has reached the conclusion that it should be possible to produce about 1,500,000 tons more crude steel than in 1955. This would raise the current year's production estimate to about 21,300,000 tons, and it has been stated that the provision of raw materials "is being arranged accordingly."

The Iron and Steel Board has said that merchants' and consumers' stocks of steel rose by about 7 per cent in 1955. At the end of last year, it is estimated that merchants held 228,000 tons and consumers 3,400,000 tons of finished steel, making a total of 3,628,000 tons. The biggest increase in consumers' stocks last year was in steel sheet; at the end of the year consumers held 530,000 tons of sheet, compared with 361,000 tons at the end of 1954.

Wage Claims

Anxiety about the economic situation generally has caused more than usual interest in the progress of wage claims which have been negotiated in recent weeks. Among claims which have been settled are those put forward on behalf of manual workers in the electricity supply industry, day wage men in the coal mining industry, and workers in the engineering and shipbuilding industries.

In the electricity supply industry, approval was given on February 10th to a wage increase of 4d. an hour to all manual workers, and an increase of £40 a year in foremen's salaries. In the coal mining industry, agreement on a wage claim was reached on February 16th between the National Coal Board and the National Union of Mineworkers. As a result of that agreement, the standard rates of craftsmen and colliery winding engine men have been raised by 2s. 8d. a shift, and the standard rates of all other adult male grades have been increased by 2s. 4d. a shift. These increases bring the weekly minimum for the lowest grade to £9 0s. 6d. (underground workers) and £8 0s. 6d. (surface workers). When the claim was first submitted, the union had asked for the merging of the five-day week bonus in the shift rate, but it has now been agreed that this matter should be deferred for later consideration. In announcing the settlement, the National Coal Board and the National Union of Mineworkers expressed their confidence that everybody employed in the industry would concentrate on improving production and efficiency, and would co-operate in all measures necessary to ensure the maximum output of coal. The union leaders, it was stated, had pledged themselves to endeavour to remove restrictive practices and reduce unofficial stoppages and absenteeism.

The terms of the settlement on engineering wages were reported briefly in our issue of March 9th, but it may be convenient to repeat them here. At a meeting, on February 29th, between the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions, it was agreed that there should be increases of 12s. 6d. a week of forty-four hours for skilled men, 11s. a week for the intermediate grades, and 9s. 6d. a week for unskilled men. On March 7th, representatives of the union confederation met the Shipbuilding Employers' Conference, and wage increases, similar to those granted in the engineering industry, were agreed for men employed in the shipbuilding and ship-repairing industries. Since then, it has been announced that, following negotiations with the Treasury, engineering workers in Government industrial establishments, including the ordnance factories, have had their wages increased by amounts identical with those agreed upon in private industry.

At the beginning of last week, a statement was made about wage increases for draughtsmen and tracers agreed between the Engineering and Allied Employers' National Federation and the Association of Engineering and Shipbuilding Draughtsmen. The increases for men are 13s., 14s. and 15s. a week, according to age, and women tracers have received an increase of 9s. 6d. a week.

Productivity and Redundancy

The British Productivity Council has published in its series of "Action Pamphlets," one entitled *Productivity and Redundancy*. The pamphlet has been prepared by a committee representative of employers' organisations and trades unions; it sets out the reasons why redundancy arises in a healthy economy and suggests how individual hardships can be avoided and how individual firms can deal with the problem.

The pamphlet points out that in a competitive world the only way to expand trade continually is to take advantage of every new technique that offers itself. It adds, however, that the rate of change is so rapid that, even in an expanding economy, there is a risk of hardship to the individuals affected. But, it is added, there is no reason why this hardship should be accepted as inevitable, and foresight and planning can do much to prevent or lessen it. The pamphlet goes on to make suggestions as to what individual firms can do about the problems of redundancy. It ends by emphasising that only a prosperous nation can go on providing new jobs to replace those that have been rendered unnecessary, and that the most efficient firms and industries will still be the surest providers of continuous employment.

Birkenhead Shipyard Strike Ends

This week the joiners at the Birkenhead shipyard of Cammell Laird and Co., Ltd., have resumed work after a strike which has lasted since November. The joiners concerned are members of the Amalgamated Society of Woodworkers, and the cause of the strike has been given as a demarcation dispute with the National Union of Sheet Metal Workers and Braziers over the cutting and drilling of aluminium sheet. As a result, work on the building of three fruit-carrying ships has been seriously delayed. A committee of inquiry, appointed by the Minister of Labour to investigate the dispute, made its report last week. The committee urged "an immediate and complete resumption of work" and said that the dispute should be settled in accordance with the general demarcation agreement which had been operating since 1912.

Progress of the Tennessee Valley Authority

BY OUR AMERICAN EDITOR

No. I

THE fiscal year 1955 brought about an unprecedented growth of the T.V.A. power system, chiefly in response to the demands of atomic defence works situated in the region. It was a record year of construction. More kilowatts of new generating capacity were added to the system than in any previous fiscal year. It was a record year of power generation. The Federal Government, for several years already the Authority's biggest customer, took more than half of the total output of the system. By far the greatest part went to the U.S. Atomic Energy Commission plants at Oak Ridge, Tennessee, and Paducah, Kentucky. It was a record year financially. Power revenues of 188 million dollars exceeded expenses, including depreciation, by 48,000,000 dollars. It was a record year of payments to the U.S. Treasury. From power revenues, 50,000,000 dollars was turned over to the Treasury. Construction toward the end of the fiscal year, however, was falling off as new generating units were completed. For the second successive year, funds for starting new generating units were not available, largely on account of political considerations. T.V.A. developed a proposal which would supplement its present sources of capital for financing new construction through the sales of bonds to be guaranteed solely by revenues from its power operations. Drafts of legislation to authorise the sale of such bonds have been submitted to the Congress.

Construction Progress

The fiscal year 1955 was an outstanding construction year, and the construction forces of the Authority added 1,734,300kW of generating capacity to the power system, the largest increase for a fiscal period in the history of T.V.A. No new power stations or dams were started, as for the second successive year funds for this purpose were not available. The record construction of new generating capacity represented projects begun under earlier authorisations, most of it undertaken to provide electric power for the plants of the U.S. Atomic Energy Commission at Oak Ridge, Tennessee, and Paducah, Kentucky. As this capacity approaches completion, construction activity is being correspondingly curtailed.

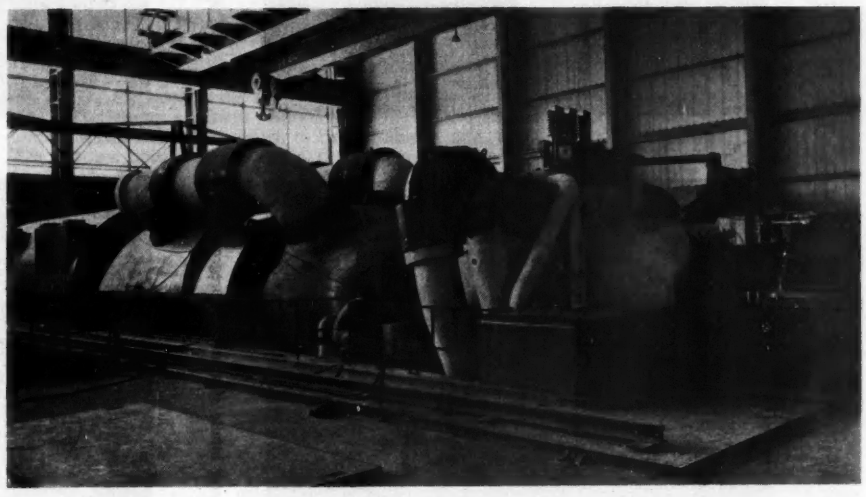
At the close of the fiscal year, the total installed capacity of the integrated system was

Projects	Number of units	Kilowatt capacity
Steam power stations :		
Shawnee	6	810,000
Colbert	4	720,000
Widows Creek	1	112,500
Kingston	1	135,000
	5	900,000
John Sevier	3	540,000
Gallatin	2	450,000
Units in existing dams :		
Douglas	1	26,000
Hiwassee	1	59,500
Chatuge	1	10,000
Nottely	1	15,000
Cumberland River (U.S. Corps of Engineers) :		
Old Hickory	4	100,000
Cheatham	3	36,000
Aluminum Company of America :		
Chilhowee	3	50,000
Tennessee Creek	1	10,800
Total capacity under construction	37	3,974,800
Capacity placed in operation	—14	—1,734,300
Capacity under construction, June 30, 1955	23	2,240,500
System installed capacity, June 30, 1955	—	7,809,985
System installed capacity, anticipated, March 31, 1958	—	10,050,485

7,809,985kW, of which 3,502,735kW was in hydro-electric plants and 4,307,250kW was in steam-electric plants. As the fiscal year ended, T.V.A. was continuing construction on an additional 2,054,500kW of generating capacity. With 136,000kW of hydro-electric capacity scheduled for the Cheatham and Old Hickory dams on the Cumberland River, and 50,000kW at an Alcoa dam on the Little Tennessee River, the integrated system will reach a total installed rated capacity of 10,050,485kW by the end of March, 1958. The table summarises the construction under way during the year on the T.V.A.-Cumberland-Alcoa generating system, the generating units completed, and the units still under construction or scheduled at the end of the fiscal year.

Steam Power Stations

For the past several years, T.V.A. has concentrated on the construction of very large steam-electric units to supply the fast-growing demand for electric power. Two of the huge atomic works in the region, both using electricity on a scale as great as the country's largest industrial centres, have brought the total power demand far beyond the hydro-electric generating capacity of the river system. The resources of the area are favourable to the development of large fuel-burning plants. Abundant supplies of coal are found within easy reach both in the region and in the adjoining territory. Alternative transport is available by rail, barge and lorry or by combinations of rail-barge or lorry-barge.



Fourth 180MW turbo-generator at the Colbert steam power station during initial operation in October 1955.

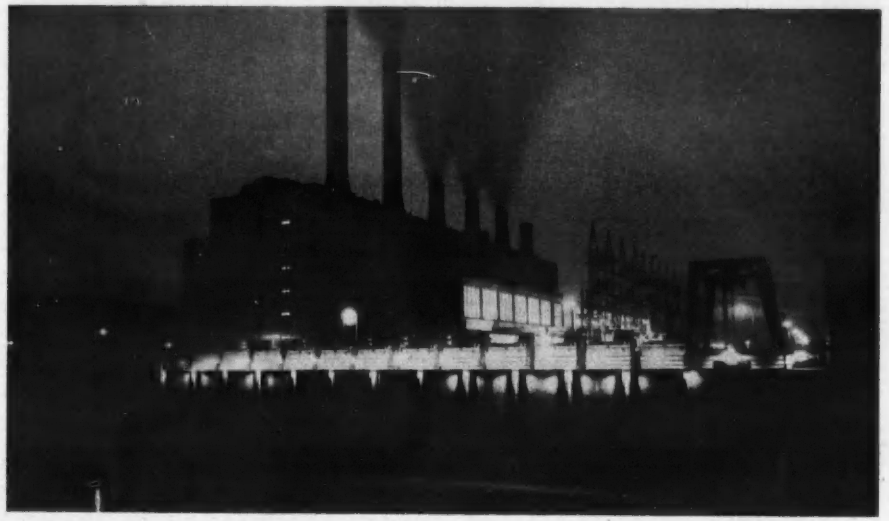
The large multiple-purpose reservoirs provide cooling or condensing water in the large quantities required. Because of the size of the T.V.A. power grid and its region-wide integration, the Authority has been able to take advantage of the economies of "bigness" and to stimulate advances in technology. Turbo-generators of unprecedented capacity and great efficiency have been purchased in multiple units of two to twelve. As a result, the new steam power stations have made excellent field laboratories for the manufacturers, providing an opportunity for inspecting and testing a whole series of machines under operating conditions. The later machines in each series could be improved from the experience with earlier installations.

When the Johnsonville steam plant was started in 1949 the 112·5MW turbo-generators were among the largest built. In the Gallatin steam plant, now nearing its initial operation, the units are exactly twice this capacity—225MW. They are believed to be the largest single-shaft 3600 r.p.m. generators in the world. The fifth unit at Kingston, the first of a series of twelve machines of 180MW capacity, was the first 3600 r.p.m. machine to operate with a revolutionary new turbine blade design.

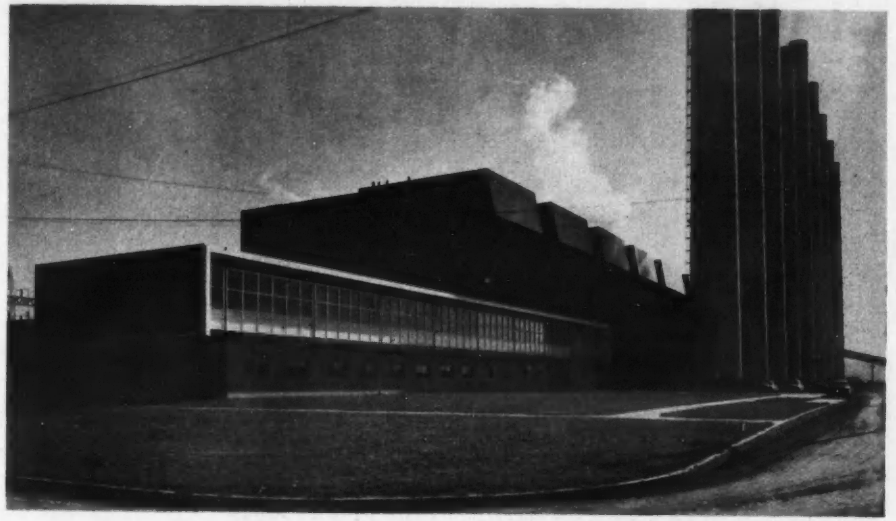
The installed generating capacity at the Shawnee steam power station was doubled during the year, with four generating units of 135MW capacity each having been placed in commercial operation. The ninth unit was in test operation at the end of the fiscal year and went into commercial operation on July 19, 1955. Good progress was made on the tenth and final unit of the plant, but completion was being delayed because of shortage of turbine parts. When complete, the power station, on the south bank of the Ohio River 12 miles west of Paducah, Kentucky, will have an installed rated capacity of 1350MW and a capability of 1500MW. The construction of the plant, with four initial units, was started in January, 1951, specifically to provide electricity for a new gaseous diffusion plant of the U.S. Atomic Energy Commission near Paducah. Subsequently, six additional units were undertaken, two for the purpose of meeting the general power needs of the T.V.A. region and the other four to meet additional power demands of the A.E.C.

During the fiscal year one generating unit of 135MW rated capacity and three of 180MW each were placed in operation at the Kingston steam power station, bringing the number of units in operation to seven. With these additions the plant at the end of the year had an installed capacity of 1080MW and a capability of 1200MW. The eighth unit at the plant was nearly ready for operation at the end of the fiscal year and went on the line on August 3, 1955. The ninth unit went into operation in November, 1955. With these two units the station was brought to a total installed capacity of 1440MW and a capability of 1600MW, making it, as far as is known, the largest steam power station in the world. The site of the plant is on the Watts Bar reservoir, about 40 miles west of Knoxville, Tennessee. Considerable delay at Kingston was caused when the twenty-third stage buckets of turbine No. 5 failed shortly after it was placed in operation. This caused particular concern, since this unit was one of twelve similar 180MW units ordered for installation in the Kingston, Colbert and John Sevier steam power stations. The manufacturer immediately commenced studies to determine the cause of the failure, using a unit at Colbert for test purposes. Meanwhile the twenty-third stage buckets were removed from the turbine and, at the request of the manufacturer, the load on the unit was restricted to 170MW. The same was done with turbine No. 6 when it was placed in operation. The manufacturer's tests revealed that the cause of the bucket failure lay in the design of the twenty-third stage diaphragm. Corrections were made, the changes incorporated in all the units, and at the end of the year all were operating at their full capabilities of 200MW each.

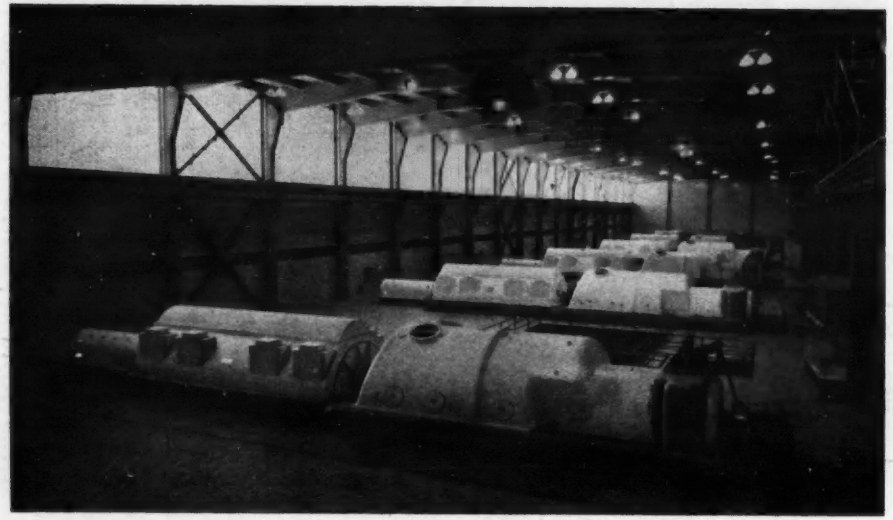
STEAM POWER STATIONS OF THE TENNESSEE VALLEY AUTHORITY



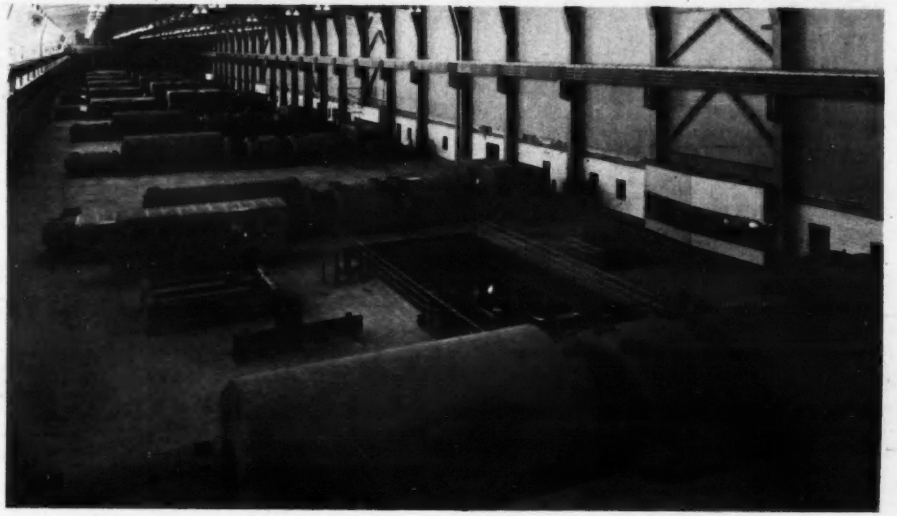
Widows Creek steam power station in Alabama, with cooling water intake structure in foreground



Kingston steam power station in Tennessee, with maintenance shop in foreground



Six turbo-generators at the Widows Creek steam power station with a total capacity of 675MW



Nine turbo-generators at the Kingston steam power station with a total capacity of 1440MW

Erection of first 225MW turbo-generator at the Gallatin steam power station in November 1955

At the four-unit Colbert steam power station in north-west Alabama on the shore of the Pickwick Landing reservoir, 12 miles downstream from the Wilson dam, two 180MW capacity generators were placed in commercial operation. At about the time the first unit was being placed in operation in December, 1954, the difficulties with a similar unit at the Kingston plant occurred. The Colbert unit was shut down, the twenty-third stage buckets removed, and the corresponding diaphragm replaced with a pressure plate ; the unit was then restored to operation at a reduced load. The second unit at Colbert, placed in operation in January, 1955, was used for extensive tests by the manufacturer, using instrumented diaphragms of both the original and modified designs. The modified design was accepted and installed, and the unit was placed in commercial operation in March, 1955, at full load. A third 180MW unit reached the operating stage in July, 1955, but at a reduced load because of conditions limiting the operating temperature of the generator. The fourth unit at the plant went into operation early in the autumn of last year. Originally, provision was made for delivery of coal at the Colbert station only by barge. A further study, however, revealed that coal could be delivered by rail from Alabama fields in sufficient quantities to justify investment in rail unloading facilities, the construction of which was then undertaken.

At the John Sevier steam power station the first of three 180MW units was being tested at the close of the fiscal year and went into commercial operation in July, 1955. The second generating unit went into operation in September and the third one in December, 1955. The John Sevier plant is situated on the south bank of the Holston River, about 4 miles south-east of Rogersville, Tennessee.

Good progress was made during the year on the Gallatin steam power station, on the north bank of the Cumberland River, about 25 miles north-east of Nashville, Tennessee. Construction was started on May 11, 1953, and the plant is to have two generating units of 225MW rated capacity each and a capability of 250MW each. Because of several delays in the promised delivery dates for the two generating units, the scheduled operating dates were put back about three months to the spring of this year. The plant will obtain cooling water from the reservoir formed by the Old Hickory dam, which is being constructed by the U.S. Army Corps of Engineers, on the Cumberland River, 26 river miles below the Gallatin site. Since the reservoir will not be filled at the time the plant is ready for initial operation in the spring, a temporary low dyke is being constructed across the cooling water intake channel near its mouth. Two of the condenser water intake pumps ordered for the plant then will be used to pump water from the river into the intake channel. It is expected that this expedient will be necessary until about August, 1956.

At the close of the fiscal year 1954 the sixth and final unit of the Widows Creek steam power station on the north-west shore of the Guntersville reservoir in north-eastern Alabama was being tested ; it was placed in commercial operation at the beginning of the 1955 fiscal year—on July 17, 1954. This brought the plant to its planned 675MW of rated capacity and 750MW of capability. During the year all the units operated satisfactorily at or above rated capacity, and the plant as a whole produced power at an average rate of 750MW, not excluding outage time for inspections. The construction of Widows Creek was started in March, 1950, and its first unit was placed in operation in July, 1952.

The Johnsonville steam power station on the east bank of the Tennessee River, about 60 miles west of Nashville, Tennessee, has been in full operation since February, 1953, when the sixth generating unit of 1125MW rated capacity and 125MW capability was placed in operation. Therefore, construction activities during the year involved completing the installation and modification of mechanical and electrical equipment which operating experience had shown to be desirable. The changes had been started in the previous fiscal year. By September, 1954, the 100ft stack extensions had been completed, raising the height of the six stacks to 270ft above ground. The automatic coal sampling system was completed in November.

Hydro-Electric Plants

For the first time in twenty-two years, no dams were under construction during the past fiscal year. Additional generating units, however, were being installed in existing dams. While most of the major dam sites in the Valley offering opportunity for large installations have been developed, some sites still remain where dams might be built to secure economical advantages of multiple-purpose water control. During the year, investigations of several of these sites were carried on. The following summarises the major construction activities at the dams during the fiscal year.

The fourth and final generating unit at the Douglas dam, on the French Broad River in East Tennessee, was placed in operation early in August, 1954. This brought the installation at the plant to 112MW, consisting of two units of 30MW capacity and two of 26MW. The Douglas dam was constructed during World War II in the record time of thirteen and a half months, in order to provide electricity for aluminium and other war production. The relatively small installed capacity of the plant belied its importance to wartime power production ; in regulating the flow of one of the principal tributaries forming the Tennessee River, this dam and reservoir increases the power production at nine downstream dams on the main river.

A single 10MW unit was placed in operation at the Chatuge dam, on the upper Hiwassee River in North Carolina, in December, 1954. The dam and reservoir project was constructed at the beginning of World War II, and the water storage it provided increased the power generation at the Hiwassee and Apalachia dams on the Hiwassee. The construction of the power station was commenced in May, 1953. The Chatuge unit has the longest penstock of any T.V.A. plant now in operation without installation of a surge tank, but tests showed that the load regulation was satisfactory and that the water hammer pressures were safely within the limits of the design pressure.

Good progress was made during the year in the installation at the Hiwassee dam of the pump-turbine unit, which is the largest such unit ever designed or built in the United States. The unit will have a generating capacity of 59·5MW, which, added to the present 57·6MW unit, will bring the installed capacity at the dam to 117·1MW. Reversed in operation and used as a pump, the unit will be able to pump water back into the reservoir against a 205ft head at a rate of 3900 cusecs. When pumping, the generator will act as a motor of 102,000 h.p. The unit will be operated as a pump on off-peak energy of low value. The water thus returned to the reservoir will help maintain the power head and will be reused through the turbines to produce much more valuable on-peak energy.

Like the Chatuge dam, the Nottely dam was constructed just prior to the United States entering World War II, to provide water storage to increase the generation of power at the Hiwassee, Apalachia and other downstream dams. It is on the Nottely River in Georgia. Near the end of the fiscal year 1954, T.V.A. commenced the construction of a power station for the installation of a single 15MW generating unit, and at the end of the 1955 fiscal year the work was well along, despite a three months' delay in the delivery of embedded turbine parts.

During the year, T.V.A. continued to make advances in engineering design and construction, with additions and improvements made at earlier schemes being incorporated in the designs of those built later. The Authority has been in a very favourable position to profit by experience. Since it has done most of its major work with its own engineering and construction organisation and employees, it has been able to perfect its organisation and to accumulate a backlog of information and practices which has produced outstanding results in planning, economy, speed of construction and effective use of engineering skills and equipment.

59·5MW pump turbine during installation at the Hiwassee dam in North Carolina

(*To be continued*)

Personal and Business

Appointments

MR. C. W. HOTCHEN has been appointed works manager (production) at Smiths Aircraft Instruments, Ltd., Cheltenham.

GROUP CAPTAIN S. O. TUDOR has joined Bristol Aero-Engines, Ltd., for liaison duties with the services and government departments.

MR. K. R. PELLY has been elected president, and Viscount Simon, vice-president, of the Chamber of Shipping of the United Kingdom.

CONCRETE, Ltd., 16, Northumberland Avenue, London, W.C.2, states that Dr. F. W. Gifford has been appointed to take charge of technical design.

OLIVER PELL CONTROL, Ltd., Cambridge Row, Woolwich, S.E.18, announces the appointment of Mr. A. C. Hall as manager of the sales department.

METROPOLITAN-VICKERS ELECTRICAL Company, Ltd., Trafford Park, Manchester, states that Mr. W. C. Clegg has been appointed assistant purchasing agent.

BRIGADIER H. F. CARTER has been appointed assistant secretary (overseas) of the Agricultural Engineers Association, 6, Buckingham Gate, London, S. W.1.

MR. W. H. LINDSEY, director and chief engineer of Armstrong Siddeley Motors, Ltd., has been appointed a director of Armstrong Siddeley (Brockworth), Ltd.

THE PLESSEY COMPANY, Ltd., Ilford, states that Mr. B. Blair, works engineer, and Mr. A. A. Chinnery, manager of the equipment division, have been appointed executive directors.

MR. C. EGGLESTON has been appointed manager of the newspaper conveyor department of Igranic Electric Company, Ltd., Bedford, in succession to Mr. H. H. Rapley who has retired.

THE LONDON MIDLAND REGION OF BRITISH RAILWAYS, states that Mr. K. Taylor has been appointed electric traction engineer, London Midland electrified lines, Manchester London Road station.

MR. A. R. MITCHELL and MR. E. R. CAMERON have been appointed directors of Yarrow and Co., Ltd., Scotstoun, Glasgow. Mr. Mitchell has been the company's naval architect since 1938.

THE NORTH-WESTERN ELECTRICITY BOARD states that Mr. John Wallace, A.M.I.E.E., has been appointed engineer of its No. 6 (Lakeland) sub-area, in succession to the late Mr. L. B. Marshall.

METROPOLITAN-VICKERS ELECTRICAL Company, Ltd., Trafford Park, Manchester, announces the appointment of Mr. G. F. Clark as assistant superintendent of the steel products department.

PROFESSOR A. V. STEPHENS has been appointed the first holder of the chair of aeronautic engineering at Queen's University, Belfast. He has been professor of aeronautics at Sydney University since 1940.

ALLIS-CHALMERS GREAT BRITAIN, Ltd., Essendine, states that Mr. Myron W. Rhoten has been appointed managing director. Mr. Donald C. Altman, manager of the industries group, has been elected a director.

MR. B. G. SCOTT has been appointed London sales manager of Lancashire Dynamo and Crypto, Ltd. Mr. V. W. Press has become sales and contracts manager of Lancashire Dynamo Switchgear, Ltd.

MR. J. M. MITCHELL, A.M.I.Mech.E., has been appointed chief engineer of the turbine department at the Fraser and Chalmers Engineering Works of The General Electric Company, Ltd., Erith, Kent.

Mr. R. J. DAWSON is to be manufacturing manager, Mr. H. G. Frommer, production manager, and Mr. W. I. Cusson, superintendent of assembly, at the factory in Glasgow which is to be opened by Caterpillar Tractor Company, Ltd.

MR. F. HAIGH has been appointed commercial manager of the steel foundry department of Edgar Allen and Co., Ltd., Sheffield. He succeeds Mr. W. Longden who is undertaking special work concerned with the investigation of costs and selling prices.

THE MINISTER OF FUEL AND POWER has appointed Mr. Sydney Smith to be chairman of the Scottish Gas Board, following the retirement of Sir Andrew Clow at the end of April. Mr. Smith is at present the chairman of the East Midlands Gas Board.

COVENTRY GAUGE AND TOOL Company, Ltd., Coventry, has announced the appointment of Mr. C. R. O. Orr as general sales manager. He succeeds Mr. H. W. Howell who has retired from that position, but who is continuing with the company for a time as a member of the chairman's personal staff.

THE BRITISH STEEL CASTINGS RESEARCH ASSOCIATION has announced the appointment of Dr. A. H. Sully as director of research. He has been associate director for the past year. In his new appointment Dr. Sully succeeds Professor R. J. Sarjant who will continue to serve the Association as an adviser.

Business Announcements

FIBREGLASS, Ltd., has acquired additional factory premises at Valley Road, Birkenhead.

MR. CLIFFORD SHAW, a director of Shaw Processes, Ltd., is making a tour of South Africa.

WEST INSTRUMENT, Ltd., has moved to 52, Regent Street, Brighton, 1 (telephone, Brighton 28106).

AUSTIN TAYLOR, Ltd., has recently opened a new works at Thorley Street, Failsworth, Manchester.

REMINGTON RAND, Ltd., has moved its Dundee office to 22, King Street, Dundee (telephone, Dundee 3875).

THE PLESSEY COMPANY, Ltd., Ilford, Essex, has opened a new factory at Leigh Park Estate, Havant, Hants.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., Norwich, states that its telephone number has been changed to Norwich 28333.

TUBULAR BARRIERS, Ltd., has opened offices at Palace Chambers, Bridge Street, London, S.W.1 (telephone, Trafalgar 5150).

THE JEARY ELECTRICAL COMPANY, Ltd., has moved its main stores to 132-142, East Road, New North Road, London, N.1 (telephone, Clerkenwell 4141).

THE EXPANDED METAL COMPANY, Ltd., Burwood House, Caxton Street, London, S.W.1, states that Mr. Ronald Scott is making a survey of markets in Canada.

DONALD ROSS AND PARTNERS, Ltd., has now moved its sales office to Twinner Works, Gatwick Road, Crawley, Sussex (telephone, Crawley 25061).

NORTHEY ROTARY COMPRESSORS, Ltd., 200-202, Alder Road, Parkstone, Poole, Dorset, states that its telephone number has been changed to Parkstone 4900.

MATTHEWS AND YATES, Ltd., Swinton, Manchester, has opened a new branch office at Jacey House, The Lansdown, Bournemouth (telephone, Bournemouth 2493).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its depot at 61a, Regent Street, Cambridge, now has an additional telephone number, Cambridge 55451.

THE SUPERMARINE WORKS OF VICKERS-ARMSTRONGS (AIRCRAFT), Ltd., is to transfer its design, technical and drawing-office sections to the main factory at South Marston, Wiltshire.

WILLIAM JESSOP AND SONS, Ltd., Sheffield, 9, is to manufacture "Hardtem" die blocks following an agreement which it has made with the Heppenstall Company, Pittsburgh, U.S.A.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the address of its Glasgow branch office and stores is now 109, Douglas Street, Glasgow, C.2 (telephone, Central 2151).

FOLLSAIN-WYCLIFFE FOUNDRIES, Ltd., Lutterworth, Nr. Rugby, states that it has taken over from International Pulverisers, Ltd., the manufacturing and selling rights of "Pulmac" mills.

TUBE INVESTMENTS, Ltd., has acquired from the Iron and Steel Holding and Realisation Agency the whole of the issued capital of the Park Gate Iron and Steel Company, Ltd., Rotherham.

TUFNOL, Ltd., Perry Barr, Birmingham, has opened a new branch office at Exchange Buildings, Quayside, Newcastle upon Tyne, 1 (telephone, Newcastle 29693). Mr. J. W. Woolley is the manager.

THE GENERAL ELECTRIC COMPANY, Ltd., states that all electronic valves hitherto sold under the trade mark "Osram" are now marketed under the trade mark "G.E.C." It should be noted that this change applies only to valves.

NEWTON, CHAMBERS AND CO., Ltd., Thorncliffe, Sheffield, has announced the retirement of Mr. G. G. Ibbotson, a local director and manager of the heavy construction department. He has been in the company's service for over forty-four years.

T. & F. PIPEWORK AND ENGINEERING, Ltd., 115-119, West Street, Bedminster, Bristol 3, states that it is no longer associated with Tubes and Fittings (Bristol), Ltd. In consequence, its name has been changed to Pipework and Engineering (Bristol), Ltd.

FOUNDRY EQUIPMENT, Ltd., Leighton Buzzard, Beds, states that arrangements have been made for it to take over the manufacture, sale and servicing of all the magnetic moulding machines hitherto produced by British Insulated Callender's Cables, Ltd.

WESTLAND AIRCRAFT, Ltd., announces that its licensing agreements with the Sikorsky Division of the United Aircraft Corporation have been extended to cover the production of a variant of the S.58 helicopter, to be powered with a 1260 h.p. Napier "Gazelle" shaft power turbine.

Miscellanea

CORRECTION.—In our report of the paper "The Use of Sodium and of Sodium-Potassium Alloy as a Heat Transfer Medium," by W. B. Hall and T. I. M. Crofts, on page 188 of our issue of February 10th, an error occurred. The sentence which reads "A very good method of steam generation would be a Loughborough system," should, in fact, have read "A satisfactory method of steam generation would be a Loeffler system."

SIR JOHN CRAIG.—Recently, Sir John Craig, C.B.E., retired from the chairmanship of Colvilles, Ltd., in whose service he has spent the whole of his long and distinguished business career. For many years, Sir John has occupied a leading position in the British iron and steel industry and especially in that important section of the industry which operates in Scotland. His unique association with and his outstanding work for the iron and steel industry is of far more than local interest, and, at the request of the board of Colvilles, Ltd., Mr. David Murray has written a short history of Sir John's career. It effectively puts on record the events of the energetic and efficient working years of one who "from office boy to chairman, for sixty-seven years, has been a Colvilles' man."

CLEARING SNOW FROM RAILWAY POINTS.—A method of clearing snow from points and crossings by the use of compressed air, which was devised by Mr. A. F. Wigram, the Signal Engineer of the North Eastern Region of British Railways, has been used with success at York. For the initial experiments a hose with a valve and pipe nozzle was connected to a tap on the air main of the electro-pneumatic point system and it was found that snow could be blown some ten yards clear of the points and crossings. A further advantage was that using air at 70 lb per square inch pressure had the effect of vaporising the snow, which just disappeared. The method was effectively used during snow storms this year and it is proposed to install seventeen nozzles to serve the whole of the York Station area.

FILMS ON GAS.—A series of fourteen films dealing with the principal aspects of gas manufacture, distribution and use has been made for the Gas Council for educational and instructional purposes. A selection of these films which was recently shown in London for the first time included the following:—"The Principles of Gas Making," "The Coke Oven," "The Gas Governor," "The Oven Thermostat," "The Horizontal Retort," "The Continuous Vertical Retort," and "The Principles of the Gas Refrigerator," Each film deals with its subject in a clear way which is easily understood by the student and interesting to the non-technical viewer. In addition to these films the Council has also prepared film strips and wall charts for use in conjunction with explanatory booklets by educational establishments.

THE ENGINEER CENTENARY NUMBER, A CORRECTION.—In printing the advertisements in our Centenary Number issued on January 4th last, even more than our usual care was taken to avoid errors. For though it is the usual practice of libraries and other bodies to omit the advertising pages when binding our weekly issues into volumes, we believe the Centenary Number is likely to be preserved intact, so that in future years it will provide a record not only, through its editorial, of what engineers were thinking, but through its advertisements of what they were making and how they drew attention to their work. We much regret, therefore, that in one firm's advertisement the title of the firm was incorrectly printed. The title of the firm advertising on page 54 of the number should have been printed Sterling Foundry Specialties, Ltd., and not Sterling Foundries Specialties, Ltd., as in fact was printed.

MOBILE INSULATING OIL PURIFIER.—A centrifugal purification equipment for insulating oils mounted on a road trailer is now being made by Sharples Centrifuges, Ltd., Woodchester, Stroud, Gloucester. The equipment incorporates a tubular bowl "Super-Centrifuge" with the necessary pumps and heater to handle the oil. If required, an equipment can also be provided with a polishing filter press for use in the treatment of switch insulating oils. The trailer for the equipment is fitted with pneumatic tyres, road brakes and the necessary towing bar for coupling it to a vehicle. Jacks provided at each corner of the trailer are used to level it up and relieve the weight on the wheels when the equipment is in operation. Two sides of the trailer body giving access to the purifier, can be provided either with roller shutters or hinged screens. These screens are hinged from the fixed top canopy and provide weather protection for the operator when the equipment is used in the open air on site.

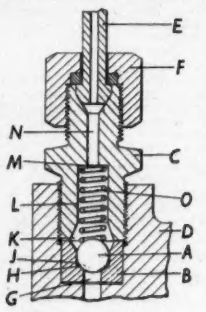
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

742,847. October 21, 1953.—DIESEL ENGINE INJECTION PUMPS, Porn and Dunwoody, Ltd., Union Works, Bear Gardens, London, S.E.1. (*Inventors: James Robertson Duff and Nigel Colin Eiloart.*)

The invention concerns a form of valve intended for use as a delivery valve between an injection pump and the pipe leading to an injector nozzle in a diesel engine. The drawing shows a preferred construction of the valve. The valve member is a ball *A*, which co-operates with a seat *B* and a union *C*. The union is screwed into the pump body *D* and holds the seat in place. A pipe *E* leading to an injector nozzle is held to the union by a cap *F*. The seat member *B* and union *C* together define an inlet *G*, a conical seat *H*, a bore *J*, an enlargement *K*, a prolongation *L* of the bore, a shoulder *M* and an outlet *N*. A compression spring *O* is confined between the ball *A* and the shoulder *M*. When the valve is closed the ball is urged by the spring against the conical seat surrounding the inlet to the valve. As the valve opens the ball moves downstream against the spring, first along a bore in which it is a sliding fit and then into an enlargement of the bore communicating with an outlet from the valve. This movement accommodates elastic expansion of the fuel and contraction of the pipe.—*January* 4, 1956.

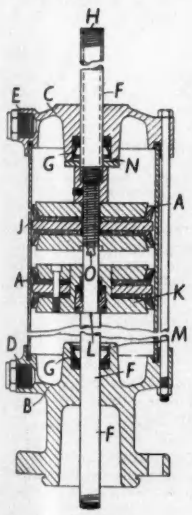


No. 742,847

WELDING PLANT

743,603. July 3, 1953.—FLUID OPERATED RECIPROCATORY MECHANISMS, Benton and Stone, Ltd., Aston Brook Street, Birmingham, 6. (*Inventor: John Hearn.*)

The invention relates to a fluid-operated reciprocatory mechanism to give both long and short strokes, its object being to provide such a mechanism in a form which is of simple construction, convenient in use, and performs its duty with economy of motive fluid. As illustrated in the drawing, there is provided a cylinder *A* of any convenient diameter, its length being appropriate to the required long stroke. End covers *B* and *C* are attached to the cylinder and one or each is provided with a pipe connection *D* and *E* through which the fluid can be admitted to and exhausted from the cylinder. The fluid may be compressed air or other gas, or a liquid under pressure. Along the axis of the cylinder is a piston-rod *F*, which along at least a part of its length is hollow so that it may be used for conveying motive air to and from the region between the pistons, this air being supplied by a flexible pipe attached to the hollow end *H* of the rod. On the piston-rod are two pistons, one of which *J* is formed on or secured to the rod, and the other of which *K* is slidable on the rod to an extent corresponding to the required short stroke. This movement is determined at one limit by contact of the adjacent faces of the pistons and at the other limit by a shoulder *L* or collar on the rod. The length of the short stroke may be adjustable by providing a screw thread connection between the piston *J* and the rod as shown, or by the provision of an adjustable collar for limiting the movement of the other piston on the rod. The range of joint movement of the pistons in the cylinder is determined by abutments *M* and *N* on the end covers. The arrangement is such that to obtain a long stroke with the pistons *J* and *K* in contact and with the piston *J* in its upper position, air at, for example, 40 lb pressure per square inch, is admitted at *E* to one end of the cylinder, causing the pistons and rod to move together through the distance permitted by the length of the cylinder and contact of the piston *K* with the abutment *M*. Subsequent short strokes are obtained by admitting air along the piston-rod and through a lateral port *O* or ports in the rod, to the region between the pistons at a pressure of, for example, 80 lb per square inch, the previously mentioned pressure in the cylinder end being maintained. The effect of the air acting between the pistons is to move the piston which is secured to the rod, the other being held by its contact with the abutment *M*, and the length of this movement is determined by the shoulder *L* or collar on the rod. In other words, the long stroke is determined by the distance between the abutment *M* and the piston *K* when both pistons occupy their upper position. The short stroke is determined by the extent to which the pistons can be separated. To obtain a succession of short strokes, air is alternately supplied to and exhausted from between the pistons, the air pressure being maintained in the cylinder end. To effect joint return movement of the two pistons, air is exhausted from the end to which it was previously admitted, and is supplied to the other end of the cylinder. Alternatively, the return movement may be effected by a spring.—*January* 18, 1956.

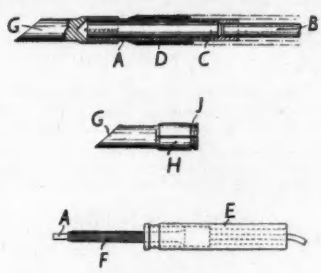


No. 743,603

TOOLS AND WORKSHOP APPLIANCES

743,664. February 16, 1953.—ELECTRICALLY HEATED SOLDERING IRONS, Robert Alfred Adamson, 35, Courtfield Rise, West Wickham, Kent.

The invention relates to electrically heated soldering irons, and its primary object is to provide a construction wherein there is little likelihood of the bit becoming fast to the body. As shown in the drawing, the body, which carries both the heater element and bit, consists of a stainless steel tube *A* into the one end of which an end of a supporting rod *B* is fixed. Within this tube is a copper core *C*. The heater element is wrapped around the greater part of the tube with the interposition of suitable insulating material such as mica. The wrapping is such that the end of the tube opposite the end connected to the rod is left projecting, to receive the bit. The outer end of the rod is secured to a handle which, as shown in the lower view, is a tube *E* and a protective cover is provided around it, such as a close-wound iron wire covering *F* which extends over it and right up to the handle. As shown, the bit *G* comprises a solid copper part having a split skirt *H* at its rear end, into which the projecting end of the tube *A* fits. The rear end of the skirt may be grooved as at *J*, and a C-spring is fitted. A pin or bolt can also be used to fix the bit, and it is preferred that the pin like the C-spring, should be made from metal resistant to tinning. The arrangement is for light irons. Irons with heavier bits can be anchored by more than one pin.—*January* 18, 1956.

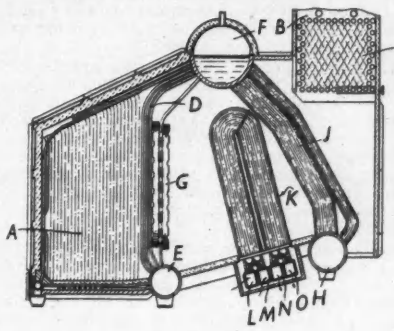


No. 743,664

MARINE ENGINEERING

743,078. March 19, 1953.—BOILER INSTALLATIONS, Foster Wheeler, Ltd., Foster Wheeler House, 3, Ixworth Place, London, S.W.3. (*Inventor: Leonard James Culver.*)

The invention relates to marine water-tube boilers. The invention can be very usefully used in a marine boiler installation having two main boilers, each supplying a set of turbines individual to it. The reheater element can be of the kind described in Specification No. 743,077, already recorded in these pages. The drawing shows a cross section through the reheat boiler, which has a furnace *A* lined with water tubes and in which combustion gases are produced which ultimately leave through a flue *B* in which is arranged an economiser *C*, and, if desired, an air heater. The furnace proper is bounded on one side by a bank of steam generating tubes *D* connecting a water drum *E* to a steam drum *F*. Immediately behind the bank *D* there is a superheater *G*. The steam drum *F* is also connected to another water drum *H* by a bank of steam generating tubes *J* and in the space between the two banks is a reheater element *K*. The reheater is arranged to take steam from two separate outside sources. As shown, it comprises two inlet headers *L* and *M*, and two outlet headers *N* and *O*, each inlet header being connected to an outlet header by U-tubes as described in detail in Specification No. 743,077, so as to provide substantially identical paths for the two streams of steam received by the inlet headers. The two streams can come, for example, from the port and starboard turbines of a two-boiler marine installation. The combustion gases generated in the furnace pass through the bank *D* and the superheater *G* and then heat the reheater element *K* before passing through the bank *J* and to the flue *B*. The reheater element is thus well shielded from the radiant heat of the furnace and is heated mainly by convection. The specification also shows diagrammatically a two-boiler marine installation having are heat boiler supplying saturated steam.—*January* 11, 1956.

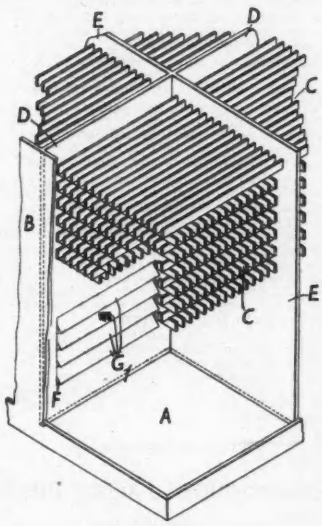


No. 743,078

COOLING TOWERS

743,793. March 20, 1953.—WATER COOLING TOWERS, Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. (*Inventor: Gerald Johnstone Williamson.*)

Improved operation of an induced draught water cooling tower has been found to be obtained by providing apertures in the lower part of the central vertical partition whereby the recirculation of air is decreased or substantially avoided. The drawing is a general view partly in section of a construction showing part of a rectangular cooling tower fitted with partitions. The walls of the tower and the layers of laths have been omitted where necessary for clarity. *A* is the base of the tower in which the tower pond is situated. *B* is part of one of the external walls. *C* indicates some of the layers of laths, and *DD* and *EE* are two internal vertical partitions extending across the tower from its top to the pond into which the lower edges of the partitions dip. In the lower part of the portion of partition *DD*, which is visible in the drawing, is a rectangular aperture *F* which extends across substantially the whole of the width. In each aperture there is a series of horizontally supported shutters *G* to form a louvre. The width of the air space between the aperture and the shutters may be adjusted by altering the angle of the shutters, for example, as in the adjustment of venetian blinds, by a mechanism which moves the shutters in unison.—*January* 25, 1956.



No. 743,793

Launches and Trial Trips

SUGAR EXPORTER, self-trimming cargo ship ; built by Hall Russell and Co., Ltd., for Silvertown Services, Ltd.; length between perpendiculars 330ft, breadth moulded 50ft, depth moulded 26ft 6in, deadweight 5325 tons on 22ft 2½in loaded draught ; four holds designed for grab discharge, electric deck machinery ; two British Polar eight-cylinder diesel engines, each of 1520 b.h.p. at 300 r.p.m. in service, drive a single shaft at 150 r.p.m. through hydraulic couplings and reduction gearing. Trial, January 23rd.

KAIMIRO, cargo liner ; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length 325ft, breadth 50ft, depth 26ft, deadweight 5300 tons ; three cargo hatches are served by twelve derricks, electric deck machinery ; Stephen-Sulzer single-acting diesel engine, six cylinders, 600mm diameter by 1040mm stroke, normal output 2410 b.h.p. at 128 r.p.m., overload power 3000 b.h.p. at 150 r.p.m. Launch, January 26th.

BONAVISTA, passenger and cargo ship ; built by Hall Russell and Co., Ltd., for Canadian National Railways ; length between perpendiculars 199ft, breadth moulded 35ft, depth moulded 19ft 6in, deadweight 1000 tons ; fifty first-class and forty second-class passengers ; three holds, electric deck machinery, two 100kW diesel-driven generators, one 50kW auxiliary generator ; Fairbanks-Morse opposed-piston, non-reversing diesel engine, 1280 b.h.p., drive through hydraulic coupling and reverse reduction gearing. Launch, January 26th.

Catalogues and Brochures

B.E.N. PATENTS, Ltd., P.O. Box No. 10, High Wycombe, Bucks.—Leaflet C.B.134, giving details of Model 300 sparking plug cleaner.

GODFREY ENGINEERING COMPANY, Ltd., 480, Metropolitan Boulevard, Montreal, 32, Canada.—Illustrated leaflet dealing with a range of "Goodenough" pumps now being manufactured under licence in Canada.

STEELS ENGINEERING PRODUCTS, Ltd., Crown Works, Sunderland.—Catalogue entitled "Mobile Handling Equipment in the Iron and Steel Industries."

BRITISH JEFFREY-DIAMOND, Ltd., Stennard Works, Wakefield, Yorks.—Publication No. 1517, giving details of the B.J.D.-Anckerton shearer-loader with ranging head.

MATLING, Ltd., Park Lane, Fallings Park, Wolverhampton.—Leaflet covering a range of floor cleansing machines, used for wet scrubbing, dry scrubbing, polishing and drying.

JOSEPH CROSFIELD AND SONS, Ltd., Warrington, Lancs.—Illustrated catalogue entitled "Dryness in Your Case," dealing with the use of "Sorbsil" brand silica gel in packaging.

JOHN GRIFFITHS AND SON, Ltd. Dudley Wood, P.O. Box No. 7, Cradley Heath, Staffordshire.—Illustrated booklet dealing with hand-forged and electrically welded chains and forgings.

GEORGE KENT, Ltd., Luton, Bedfordshire.—Publication No. 966/1155, dealing with electrical systems for transmitting, over a distance, measurement of flow, level and similar functions ; and publications No. 1503, 1504, 1505/1255, giving details of 200in, 400in and 600in mercury U/S chamber and U-tube unit.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., 21, Bloomsbury Street, London, W.C.1.—Illustrated booklet dealing with paper-insulated cables, solid type lead-sheathed for voltages up to 33kV. The cables described in this booklet conform to Part I of British Standard 480 : 1954, for cables with sheaths of lead and lead alloy.

HIGH DUTY ALLOYS, Ltd., Slough, Bucks.—Booklet entitled "Beginning of an Adventure," giving details of the company's apprenticeship scheme and of the facilities available for furthering education. The directors invite interested parents, career masters at schools and employment officers to communicate with the personnel manager at their local division.

STURTEVANT ENGINEERING COMPANY, Ltd., Southern House, Cannon Street, London, E.C.4.—Publication No. 2004, entitled "Dust : Characteristics, Problems and Control." The booklet is composed of three main sections with many sub-divisions. Sections 1 and 2 deal mainly with brief scientific data concerning the characteristics of dust ; Section 3 describes the main characteristics of dust filters.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, April 6th.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "Variable Speed Motors," F. T. Bartho, 7.30 p.m.

Mon., April 9th.—CENTRAL LONDON BRANCH : St. Ermin's Hotel, Caxton Street, London, S.W.1, "Internal Distribution Systems in U.S.," E. J. Sutton, 7 p.m.——LEEDS BRANCH : Great Northern Hotel, Leeds, "Relays," Mr. Smith, 7.30 p.m.——N.W. LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, Technical Film Show, P. A. Thorogood, 8.15 p.m.

Tues., April 10th.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Films, "Railway Electrification," "Linesmen Over Thames," and "Building Britain's Grid," 8 p.m.——LUTON BRANCH : Midland Hotel, Williamson Street, Luton, "Instrumentation and Control of Industrial Processes," L. E. Meeks, 8 p.m.——W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, "Electric Floor Heating," R. D. Jackson, 7.30 p.m.

Wed., April 11th.—BIRMINGHAM BRANCH : Room 3, Chamber of Commerce, New Street, Birmingham, "High-Frequency Heating," Mr. Cosier, 7.15 p.m.——HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, "Motor Control Gear," R. F. Mathieson, 7.30 p.m.——S.W. LONDON BRANCH : Guild House, 32, Worple Road, Wimbledon, "Electrical Hazards and Electrical Safety," S. J. Emerson, 8.15 p.m.

Fri., April 13th.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, "Mineral Insulated Lighting, Power and Heating Cables," R. J. Cotton and R. W. Sutherland, 7.30 p.m.

BATTERSEA POLYTECHNIC

Tues. to Fri., April 10th to 13th.—DEPARTMENT OF METALLURGY : London, S.W.11, A Vacation Day Course on "The Heat-Treatment of Steel," 10 a.m.—5.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, April 6th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "The Importance of Visual Aids in the Teaching of Advanced Radio and Electronic Engineering," discussion opened by R. H. Garner, 6.30 p.m.

Wed., April 11th.—SCOTTISH SECTION : Department of Natural Philosophy, University of Glasgow, "The Glasgow University Synchrotron," a visit and lecture on its principles and application, 7 p.m.——MERSEYSIDE SECTION : Council Room, Chamber of Commerce, 1, Old Hall Street, Liverpool, 3, Annual General Meeting, followed by technical films, 7 p.m.——N.E. SECTION : Neville Hall, Westgate Road, Newcastle upon Tyne, Annual General Meeting, 6 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., April 10th.—Park Hotel, Cardiff, Conference on "The Cost of Steam," 10.15 a.m. to 12.30 p.m. and 2.15 p.m. to 4 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., April 10th.—SESSIONAL MEETING : Gaumont-British No. 1 Theatre, Film House, 142, Wardour Street, W.1, Symposium on Screen Viewing, L. Knopp, S. T. Henderson and R. D. Nixon, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., April 12th.—BEDS AND HERTS SECTION : W. H. Allen, Sons and Co., Ltd., Bedford, "Some Foundry Problems," G. J. Rogers, 7.30 p.m.

Fri., April 13th.—TEES-SIDE BRANCH : Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, Annual General Meeting. Presentation of Awards, Apprentice Competition, followed by a reading of the prize winning entry in the Short Paper Competition, 7.30 p.m.

INSTITUTE OF FUEL

To-day, April 6th.—N.W. SECTION : Engineers' Club, Albert Square, Manchester, Annual General Meeting, followed by an address by G. Nabarro, 2.30 p.m.——S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, "Modern Applications of Oil Firing," R. J. Baldry, 6 p.m.——SCOTTISH SECTION : Royal Technical College, Glasgow, Annual General Meeting, 7 p.m.

Mon., April 9th.—N.E. SECTION : Stephenson Building, Newcastle upon Tyne, Annual General Meeting, followed by a film, "Powered Flight," 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., April 10th.—85, Minories, London, E.C.3, "Recent Developments in Marine Diesels," a symposium, 3.30 p.m. and 5.30 p.m.

Thurs., April 12th.—W. MIDLANDS SECTION : Birmingham Exchange and Engineering Centre, Birmingham, "Design and Operation of Steam Turbines for High Pressures and Temperatures," R. Ecker, 7 p.m.

INSTITUTE OF METALS

Fri., April 13th.—Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, "Electron Emission from Metals," Erich Schmid, 2.30 p.m.

INSTITUTE OF PETROLEUM

Wed., April 11th.—26, Portland Place, London, W.1, "The Oil Industry—Its Place in the World and Its Future," J. W. Platt, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 9th.—SCOTTISH CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Use and Abuse of Tyres," G. H. I. List, 7.30 p.m.

Tues., April 10th.—MIDLANDS CENTRE : Birmingham Exchange and Engineering Centre, Birmingham Centre Annual General Meeting, 7 p.m.

Wed., April 11th.—E. REGIONAL CENTRE : Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, Centre Annual General Meeting, 7.30 p.m.——E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "Some Factors Affecting Fuel Consumption," W. T. Skinner, 7.30 p.m.

INSTITUTE OF WELDING

Mon., April 9th.—SHEFFIELD BRANCH : Grand Hotel, Sheffield, Annual General Meeting, followed by films and discussion, 7.15 p.m.

Wed., April 11th.—LEEDS BRANCH : Griffin Hotel, Leeds, Annual General Meeting and Discussion Night, 7.30 p.m.

Thurs., April 12th.—N.E. (TYNESIDE) BRANCH : Mining Institute, Neville Hall, Newcastle upon Tyne, "Structural Steelwork, with Special Reference to Welding," E. R. Bowers, Annual General Meeting, 7 p.m.——N. LONDON BRANCH : Manson House, Portland Place, London, W.1, Annual General Meeting and Technical Discussion, 7.30 p.m.——S. LONDON BRANCH : 2, Savoy Hill, London, W.C.2, Annual General Meeting and Film Show, 6.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., April 10th.—The Geological Society, Burlington House, Piccadilly, London, W.1, "Patents in Chemical Engineering," H. I. Downes, 5.30 p.m.

Wed., April 11th.—N.W. BRANCH : The University, Leeds, "Commissioning a Major Coal-Preparation Plant," A. J. C. Older, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, April 6th.—YORKSHIRE ASSOCIATION : Hotel Metropole, Leeds, "Design and Construction of Aden Oil Harbour," J. E. G. Palmer, 6.15 p.m.

Tues., April 10th.—ROAD MEETING : Great George Street, Westminster, London, S.W.1, "Design of Road Intersections," Kenneth Summerfield, 5.30 p.m.

Thurs., April 12th.—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, "Observations on Public Health Engineering in the U.S.A.," R. J. Cornish, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Sat., April 9th to 14th.—MEASUREMENT AND RADIO SECTIONS : Convention on Digital-Computer Techniques. *April 9th to 12th* : Savoy Place, London, W.C.2 ; *April 13th and 14th* : Visits to typical computer installations.

Tues., April 10th.—LONDON GRADUATES' AND STUDENTS' SECTION : R.E.M.E. Training Centre, Bailleul Barracks, Arborfield, Berks, "A Survey of the Various Types of Tacho-generators Suitable for Control Applications," L. J. Jones, 7 p.m.——N. MIDLAND CENTRE : Royal Station Hotel, York, "The Standardisation of Retail Electricity Tariffs," A. O. Johnson and N. F. Marsh, 7 p.m.

Wed., April 11th.—N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "Highland Water Power," (the late) T. Lawrie, 7.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., April 9th.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "The Polishing of Diamonds," T. P. N. Burness, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., April 10th.—39, Elmbank Crescent, Glasgow, Annual General Meeting, "Mechanisation in the Fishing Industry," W. Lochridge, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Wed., April 11th.—E. MIDLANDS BRANCH : County Hotel, Nottingham, Annual General Meeting. John Hughes' Prize Night, 6.45 p.m.

Thurs., April 12th.—BIRMINGHAM AND DISTRICT BRANCH : Birmingham Exchange and Engineering Centre, Birmingham, Annual General Meeting, "Some Solutions to Heating and Ventilation Problems in Atomic Energy Research Establishments," G. M. Harbett, 6.30 p.m.

Fri., April 13th.—MANCHESTER AND DISTRICT BRANCH : Engineers' Club, Albert Square, Manchester, "Small Pipe Forced-Circulation Central Heating," S. A. Burke and D. V. Brook, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 11th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Evolution of the Internal Combustion Locomotive," J. M. Doherty, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 6th.—GENERAL MEETING, INTERNAL COMBUSTION ENGINE GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "A Standard Gas Turbine to Burn a Variety of Fuels," G. B. R. Feilden, J. D. Thorn and M. J. Kemper, 5.30 p.m.

Tues., April 10th.—N.W. A.D. CENTRE : Leyland Ltd., Manchester, "Commercial Vehicle Structure," P. Brunton, 7.15 p.m.

Wed., April 11th.—YORKSHIRE BRANCH : Technical College, Chesterfield, "Fatigue of Metals," J. A. Pope, 7.30 p.m.

Thurs., April 12th.—YORKSHIRE BRANCH : Chemistry Lecture Theatre, The University, Leeds, "Copying Devices and Tracer-Controlled Machine Tools," H. C. Towne, 7.30 p.m.

Fri., April 13th.—GENERAL MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS GROUP : 1, Birdcage Walk, London, S.W.1, "Fatigue Under Triaxial Stress : Development of a Testing Machine and Preliminary Results," J. L. M. Morrison, B. Crossland and J. S. C. Parry ; "The Fatigue Strength of Specimens Containing Cracks," N. E. Frost and C. E. Phillips, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

To-day, April 6th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Repair of Telephone Instruments by Mass Production Methods," W. H. Maddison, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., April 10th.—OXFORD SECTION : Town Hall, Oxford, "The Human Aspects of the Advent of the Automatic Factory," W. J. Carron, 7.15 p.m.——LONDON GRADUATE SECTION : Institution of Production Engineers, 10, Chesterfield Street, W.1, Annual General Meeting and Film Evening, 7.15 p.m.

Wed., April 11th.—PETERBOROUGH SECTION : White Lion Hotel, Church Street, Peterborough, "The Metallurgist in Production Engineering," E. Beven, 7.30 p.m.

Thurs., April 12th.—ROCHESTER SECTION : Assembly Room, Sun Hotel, Chatham, Annual General Meeting, followed by films, 7.30 p.m.

Fri., April 13th.—W. WALES SECTION : Central Library, Alexandra Road, Swansea, "Human Relationship and Production," R. D. Young, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., April 12th.—11, Upper Belgrave Street, London, S.W.1, "Road Bridges in Norway," Armulf Arild, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 6th.—Pepys House, 14, Rochester Row, London, S.W.1, Film Evening : "Beneath the Flames," "Thin Film Lubrication," "Lubrication Greases," "Cutting Oils," 7 p.m.

Mon., April 9th.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, "Motor Bus Maintenance," T. F. Bailey, 7.30 p.m.

Wed., April 11th.—MIDLAND SECTION : Stewart and Lloyds Lecture Hall, Bilston, Chairman's Address, J. H. Price.

Fri., April 13th.—ORDINARY MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Steam Turbine Principles and the Characteristics of the Various Types," P. A. Frowley, 7 p.m.

NEWCOMEN SOCIETY

Wed., April 11th.—Science Museum, Exhibition Road, South Kensington, London, S.W.7, "Upright Shafts in Windmills," Rex Wailes ; "The Crampton Locomotive in England," P. C. Dewhurst, 5.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, April 6th.—Mining Institute, Neville Hotel, Newcastle upon Tyne, "Experiments with Tanker Models," H. Edstrand, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., April 12th.—SECTION DISCUSSION : 4, Hamilton Place, London, W.1, "Aircraft Interior Layout," 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 9th.—ORDINARY GENERAL MEETING : 12, Great George Street, London, S.W.1, "Rating—The Past, the Present, and the Future," Francis G. Fleury, 5.30 p.m.

SOCIETY OF ENGINEERS

Mon., April 9th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Technical Developments in Laying Gas Mains," F. G. Laming, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, April 6th.—Engineering Laboratory, Cambridge, Conference on Plant and Process Dynamic Characteristics.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., April 13th.—39, Elmbank Crescent, Glasgow, "Thermal and Chemical Behaviour in the Open-Hearth Furnace," P. T. Carter, W. G. Cameron and R. Hay, 6.45 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., April 11th.—MANCHESTER BRANCH : Visit to Thos. Hulbert and Sons' Flour Mills, 7 p.m.